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A WATER FILTRATION ORDINANCE for Philadelphia will probably be submitted soon to the Council's Water Committee by the Director of Public Works, Mr. Thos. M. Thompson. Meanwhile, Mr. Thompson will be relieved from consideration of the numerous bills looking to the filtration of the city water supply by private companies which have been referred to him during the past few weeks. This action is the result of a conference between the committee and the director, during which the latter plainly stated that he was tired of making reports which received little or no attention from the councils. He also urged the necessity of a thorough expert study of the filtration question, for which an appropriation would be necessary, in order to pay for outside advice and the other expenses of the investigation. An event which may have an important bearing upon the water question at Philadelphia is the ignoring by the Grand Jury of the bills of indictment for bribery in the Schuylkill Valley Water Co. matter. It may be remembered that an ordinance providing for a filtration contract with this company was being rushed through the councils last summer, when assertions on the floor that money had been paid for votes caused the indefinite postponement of the ordinance. The matter went into the courts, and the press and public seemed convinced that the charges were true. Greatly to the surprise of the citizens, the bills of indictment found by the judges have been ignored by the Grand Jury, so the cases must be dropped. It is said that the Schuylkill Valley Water Co. will bring in a new proposition early next year. This seems probable enough, for in the face of all the excitement and apparent defeat attendant upon the alleged exposures last summer, the company, it is said, moved into large and commodious new offices. Possibly the withdrawal of other private schemes from the consideration of the director of public works is intended to clear the way for the Schuylkill Valley Water Co. This company is said to be composed largely of Providence and New York capitalists, and to have organized two subsidiary companies; one a land and storage company, probably for the acquisition of real estate, and the other, known as the Providence Construction Co. Mr. Nelson G. Green, 309 Broadway, New York city, is special agent for the Schuylkill Valley Water Co.

EXPERIMENTS ON THE USE OF OZONE for water purification are described at some length in London "Engineering" for Nov. 11 and 18. A briefer and more judicial account of the same experiments is given in the report of the Maine State Board of Health for 1896 and 1897, under "Notes on Disinfectants and Disinfection." The experiments have been made in Germany and Holland during the last six or seven years. Ozone is produced from air by means of high tension electric currents, ranging from 50,000 to 100,000 volts. Thus far the results obtained seem to be of no practical importance, so far as public water supplies are concerned. If the water to be treated with ozone is high in organic matter it is filtered first, at a rate, in some of the experiments, of about 4,000,000 gallons an acre. The ozone seems to be used principally to render the water absolutely sterile, which it apparently does. The expense of the process is not stated.

THE EXTENSION OF STREET RAILWAY FRANchises in Chicago for a period of 50 years, referred to in our last issue, continued to agitate the people of that city through another week. On Dec. 19, the council voted to withdraw the ordinance, 40 to 23. A motion to refer the ordinance to a committee friendly to Mayor Harrison, and against the extension, was carried by a bare majority of one, the vote being 32 to 31. Five members of the council were absent when these votes were taken. The opponents to the extension demand that no ordinance be passed until the Allen law is repealed. This law was passed by the last legislature, under very suspicious circumstances, and gives authority for the proposed extensions.

A COMBINATION OF STREET LIGHTING COMpanies, East of the Mississippi River, is announced from Philadelphia as going into effect on Jan. 1. An alleged infringement of gaslight patents by rivals of the Pennsylvania Globe Gas Light Co. is said to be the cause of the new consolidation. The deal provides for a capitalization of $12,000,000, and the companies involved are the following: Pennsylvania Globe Gas Light Co., Welsbach Street Lighting Co. of Chicago, New York and New Jersey Gas Light Co., of New York; the Chicago Globe Gas Light Co., the Canton Globe Gas Light Co., of Canton, O.; the Kitson Incandescent Gas Light Co., and two other companies not named. The deal carries with it four large factories, and 60,000 lights in different cities, soon to be increased by 50,000 lights contracted for by the Kitson Co. The Welsbach Co. is operating its system in 50 different towns. Except the Kitson, all these companies are controlled by the Pennsylvania Globe Gas Light Co., of which the stock is owned and controlled by the United Gas Improvement Co., of Philadelphia, or the Widener-Elkins-Dolan syndicate. The Kitson Co., for its $3,000,000 stock, gets $3,000,000 common stock of the new company, out of the $6,000,000 common stock authorized. Of the $6,000,000 preferred stock, $5,000,000 goes to the United Gas Improvement Co., along with the other half of the common stock; $400,000 preferred will cover cash in the treasuries of the two companies, and the remaining $600,000 preferred will be left in the treasury.

ANOTHER CABLE-ROAD WILL BE TRANSFORMED to a conduit electric system. The Columbia Railway of Washington, D. C., notwithstanding the fact that it has a modern cable plant in perfect running order, will follow the example of the Capital Traction Co., of that city, and adopt the conduit electric system.

COMPRESSED AIR now seems to absorb the attention of Mr. Joseph Leiter, who came into prominence last fall as a wheat manipulator, and it is reported that he has secured the controlling interest in the International Air Power Co., of New York, capitalized at $7,000,000 with the intension of extensively introducing it as a motive power for street railways, motor vehicles, etc.

A $5,000,000 CONTRACT FOR STEAM AND ELECTRICAL machinery has been awarded to the Westinghouse Electric & Machine Co., of Pittsburg, Pa., by the Third Avenue R. R. Co., New York city. The plans of the railway company, in so far as they have been announced, include the erection of an immense power-house with a capacity of about 64,000 HP. on the company's property at 216th St., New York city. The conduit electric system will be installed on all of its lines. It is also understood that the company contemplates the sale of surplus power after the plan proposed by the Metropolitan Traction Co.

THE NEW YORK RAPID TRANSIT COMMISSION, at its meeting on Dec. 15, decided to apply to the legislature to be relieved of the impediment of the municipal debt limit, and to be empowered to carry out its enterprise, either by the aid of private capital, or by issuing bonds upon the county of New York alone. The bill is being prepared for presentation.

THE ANNOUNCEMENT that $40,000,000 is to be expended for public works in Greater New York, and that improvements are to be energetically pushed next year, comes as a surprise to those who lately heard so much of the debt limit being exceeded, etc. About $10,000,000 of this sum has already been authorized, and the power to raise the remaining $30,000,000 is to be provided for by an increase of $400,000,000 in the assessed valuation of property in the city.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred Dec. 15, on the Florida Central & Peninsular R. R., near Madison, Fla., as the result of a passenger train running into some cattle that were on the track. Six persons were killed.

A SERIOUS ACCIDENT occurred, Dec. 13, on the New York Central & Hudson River R. R., near Grimesville, N. Y., in which 8 men were killed and several injured. A gang of from 60 to 70 men were shoveling snow from the tracks and moved out of the way of a west-bound freight, when their attention was attracted by an east-bound passenger train. In getting out of the way of this second train several of them walked in front of the Atlantic Express, which had run down upon them unheard.

THE FAILURE OF THE IRELAND BUILDING, in New York city, which took place on Aug. 8, 1895, and was discussed at length in our issues of Aug. 15, 22, and 29, 1895, is recalled to mind by a verdict for $10,000 damages against Mr. John B. Ireland, the owner of the building, by the widow of John Burke, one of about 15 men who were killed by the accident. A year ago a similar verdict was obtained in the same case, but it was set aside on account of defective proof. In that suit the jury exonerated the contractors, holding that the construction was under the personal supervision of the architect, the direct agent of Mr. Ireland. The Coroner's jury, which made a long investigation after the accident, held responsible the architect, his assistant, the contractor, his superintendent, the mason foreman, and an ex-inspector of the Department of Buildings, and the Grand Jury afterwards found indictments for manslaughter against all of these men, but we believe their cases were never brought to trial. Other damage suits against Mr. Ireland are likely to follow the verdict now given.

A SAFETY GATE FOR DRAWBRIDGES, which is now in use at the Randolph St. bridge over the Chicago River, in Chicago, is similar in design to the gates extensively used at railway grade crossings, having vertically moving arms which extend across the roadway and sidewalk when the bridge is open. The apparatus and operation are very simple. Across the bridge run two transverse shafts, carrying four sprocket wheels, while four other sprocket wheels are mounted on vertical spindles at the corners of the bridge. Short lengths of sprocket chains pass round the wheels and are connected by light wire ropes. On the four spindles are four spur wheels, which have teeth 1¼ ins. long, in order to allow for the contraction and expansion of the bridge. These wheels engage with sprocket wheels on the abutments. Chains from these operate wheels under the gate posts, which in turn operate the gate arms by vertical chains enclosed in the cast-iron boxes or posts of the gate. The shafts on the bridge are operated by sprocket gearing by means of crank handles, the chains being enclosed in a small box or housing. When the bridge is to be opened, electric gongs on the approaches are rung by means of a push button on the housing of the operating gear. The bridge tender then operates one crank, thereby closing the diagonally opposite gates against the traffic, while leaving the other gates open to permit teams and persons already on the bridge to pass off. When the bridge is clear he operates the other crank and closes these latter gates. The bridge is then swung open in the usual way, leaving the gates locked. Each gate arm is made of two bars, which are brought together at the outer ends and spread apart so as to embrace the gate posts, the bars being connected by bracing. The gate is the invention of Mr. H. A. Paquette, of Chicago, and is being introduced by the Chicago Bridge Gate Co., 7114 Cottage Grove Ave., Chicago, Ill.

A FIRE DESTROYED the frame building used by Mr. Allen Hazen, Assoc. M. Am. Soc. C. E., as a branch office during the construction of the filtration plant at Albany, N. Y., and located at 57 Lumber District, of that city. Many valuable records, photographs and plans, relating to the work were burned. Mr. W. B. Fuller, M. Am. Soc. C. E., Resident Engineer, had a very extensive library of engineering literature and private memoranda and several valuable surveying and calculating instruments which were all destroyed. Mr. John H. Gregory, First Assistant, also lost a large number of engineering books. There was no insurance. The unfortunate experience of these engineers would serve as a warning to engineers generally as to the wisdom of keeping books, drawing instruments, etc., insured, even when they are housed in temporary quarters on construction works.

THE PARIS EXPOSITION OF 1900 is the title of a circular letter recently issued by Mr. Francis E. Drake, Director of Machinery and Electricity of the United States Commission, in which the location of the buildings is briefly given and the general conditions of installation and exploitation of steam boilers, general conditions of installation of the engine dynamo group and the conditions for the construction and operation of a number of inclined electric elevators are given in detail.

THE PARIS EXPOSITION AUTHORITIES have awarded to the United States a total of 250,000 sq. ft. of space; but the demands from this country already call for 700,000 sq. ft., says U. S. Commissioner Benjamin W. Wobdward.

THE RECENT PARIS MOTOR-CAB COMPETITIONS.

In February, 1897, the Automobile Club of France decided to hold in Paris an international competitive trial of motor vehicles adapted to regular service as cabs in the streets of Paris. As a basis of comparison with the present cab service, it was decided, upon investigation, that the average daily run of a cab in Paris was about 40 miles; of which 28 miles were devoted to useful work, while the remaining 12 miles were consumed in passing between the stables and cab

Fig. 1.—Peugeot Coupe; petroleum motor.

stands and in driving about the streets in search of passengers. The time thus covered was 16 hours per day.

Based upon this estimate, the conditions of the competition required the mechanically propelled cabs to make a run of 40 miles in 16 hours over routes specified, with but two halts; one of half an hour and one of one hour for breakfast. This run was to be made for 12 consecutive days over 12 different routes, selected with reference to gradients. Within the City of Paris the speed was not to exceed 20 kilometers, or 12.4 miles per hour; the speed on grades was to be recorded mechanically; and each vehicle was required to make the 12 trips with the complement of passengers and baggage called for in its design, or to carry corresponding weights of 154 lbs. for a passenger and 66 lbs. for baggage. The detailed official report upon this trial is contained in "Le Genie Civil" for Sept. 3, 10 and 17, with illustrations of the motor-cabs used. A brief description of the vehicles and some of the conclusions arrived at follows:

In all 26 motor vehicles entered the race of last June, of which 14 were equipped with electric motors and 12 were operated by petroleum distillate engines. To feed the former a temporary but fully equipped electric generating plant was installed near the place of storage for the vehicles. As a basis for comparison of cost, the daily expense of running an ordinary Paris cab pulled by a horse was fixed at 19.26 francs, or $3.85. This sum included expenses of administration, rent of stables, repairs, horse-feed and attention, pay of driver, taxes and material, and it included the average use of 3½ horses per cab employed.

The first class of vehicles entered covered those with a single motor, where the power is transmitted to motor wheels through an intermediary; with gearing permitting a mechanical variation in speed. Under this head came the Peugeot coupe as a type (Fig. 1), propelled by a gas-engine and intended to carry three passengers, without baggage, or a useful load of 462 lbs. This vehicle was made up of a closed body, with two seats capable of carrying four passengers, and it did frequently carry this number during the trial. The driver or operator has his seat in front, and controls the apparatus for directing and changing speed and operates a brake-pedal. Attached to this front part is the naptha reservoir. The motor is placed in the rear of the carriage-body. The naptha reservoir, holding 35 litres, is in the driver's seat, and the water reservoir, holding 38 litres, is under the vehicle. The total weight is 2,838 lbs., with 1,509 lbs. on the front wheels and 1,329 lbs. on the back wheels. The out-to-out width of the vehicle was 5.25 ft., and the total length was 9.18 ft.

The motor used, with petroleum distillates, was built on the Peugeot system, the charge being exploded by incandescent tubes. It developed 6 HP. and weighed 231 lbs., with its fly-wheel and bed-plate. The two cylinders are horizontal; 96 mm. diameter; 32 mm. stroke, and the normal revolutions were 680 per minute. These cylinders are cooled by the circulation of water, pumped from the water-tank around the cylinders and back to the tank. The motor-shaft is horizontal and parallel to the axle-tree, and it is connected with the shaft carrying the speed-differential by a friction-gear, which permits four changes of speed—3.7, 6.2, 9.3 and 12.4 miles per hour, and a backward speed of 9.3 miles. For braking purposes there is a ribbon-brake, lined with camel-skin, and working upon the box of the differential by means of the pedal.

The full detail of the test of this Peugeot motor is too long for insertion here, but some of the more important results are as follows: The average speed made was 14 miles per hour, with 3.7 miles per hour on an 8.2% grade. The jury figured that the daily cost of running this vehicle was $5.55; of which sum $2.17 was for oil, etc., consumed, and $3.28 was for other expenses.

Under the head of electrical motors the Jenatzy coupe (Fig. 2) is taken as a type. This cab was intended to carry two passengers, or a useful load of 308 lbs. It was made up of the ordinary cab-body with a bracket-seat, though this third seat was not used for a passenger during the trial. The driver sat in front and there handled a directing-bar, speed-variant and brake combined, and under foot was a pedal operating a friction-brake. The total weight was 3,964 lbs.; with 1,854 lbs. on the front wheels. The wheels were made of wood with metal hub, fitted with Michelin pneumatic tires. The extreme width of the vehicle was 5.9 ft., and the extreme length 9.2 ft.

The motor, speed-gearing and differential are enclosed in the body of the vehicle. The motor, excited in series, has a normal power of 4 to 5 HP.; but it may easily develop, according to the claim of the builder, 10 to 12 effective HP. Two normal speeds are arranged for—3.7 and 7.4 miles per hour; for the first speed the two batteries are connected in parallel, and for the second speed, in series. Special gearing is provided for passing from 3.7 to 5.6 miles speed, and from 7.4 to 12.4 miles speed, and intermediate speeds can be obtained by introducing momentary resistance coils. The accumulators are of the Fulmen type, B 21, forming two batteries of 22 elements each; each enclosed in a box; one under the driver's seat and one behind the carriage. These two boxes are easily opened for taking out and replacing the batteries.

The general speed results were as follows: On the level the batteries in parallel gave an average speed of 5.27 miles per hour; in series they gave

Fig. 2.—Jenatzy Coupe; accumulator system.

a speed of 10.4 instead of the promised 11.2 miles per hour. On a grade of 8.2% the batteries in series gave a speed of 4.9 miles per hour. The jury figured that the daily cost of operating the Jenatzy coupe was $4.05, of which 80 cts. was for the repairs to the accumulators and 34.4 cts. was for the electricity; the rest went for general expenses.

The second class in the test included vehicles with a single motor, where power is transmitted by motor-wheels by means of invariable gearing, with a differential and chains; and where the variation in speed is secured by a corresponding variation in the speed of the motor. Under this head the electrically propelled Jeantaud cab (Fig. 3) is taken as a type. This cab is intended to carry two passengers, or a useful load of 308 lbs. It can be made to be sold for $2,800. It is a four-wheeled cab, with the forward wheels carrying a box enclosing the accumulators; the driver is behind, and there controls all movements. The motor and differential gear are under the cab. The total weight of the cab is 3,102 lbs., with 1,419 lbs. over the front wheels. The wheels are wood

Fig. 3.—Jeantaud Cab; accumulator system.

with metallic hub and Michelin pneumatic tire; the extreme width of the vehicle is 5.08 ft., and the extreme length is 9.7 ft.

The motor and shaft of the differential are placed in a closed box, with the ends of the differential shaft projecting and carrying pinions for the sprocket chains; this motor, with its transmission gear, weighs 330 lbs., and has a normal power of 3½ to 4 HP. Different variations of excitation and the coupling of the batteries permit speeds ranging as follows: 4.34, 7.44, 9.3 and 11.2 miles per hour. Intermediate speeds are obtained by momentary resistances introduced through the pedal of the electric brake. The accumulators are of the Fulmen type, B 15; they contain 44 elements and weigh in all 880 lbs. Transmission is by a sprocket-wheel and chain connecting the ends of the differential-shaft and the corresponding motor-wheel.

The mean maximum speed made in the trial was 10.5 miles per hour; the daily cost of running this cab was fixed by the jury at $3.96.

A Jeantaud landaulet, Fig. 4, was also submitted to test, which carried two passengers and cost $2,800. It weighed 3,652 lbs. Fulmen accumulators, B 17, weighing in all 1,005 lbs., were used, and the general plan of transmission, etc., was similar to the cab first described. The daily cost of operation was fixed at $4.04.

The third class of vehicles included those with two motors, one for each motor-wheel; geared directly to it with no provision for change of speed, except by changing the speed of the motor.

To this type belonged the Krieger carriage, Fig. 5, arranged so that the body of the carriage could be changed without interfering with the motor mechanism. The coupe and victoria types would carry three or four passengers without baggage; the useful load is 462 lbs., though in the trial they often carried 616 lbs. Either of these carriages could be sold for $2,400 each.

In these carriages the accumulators are stored in two boxes; one under the seat of the driver, and one behind the body of the carriage. There are two motors, one for each front wheel, and these are both motor and directing wheels, the motors being placed directly over the vertical pivots. The coupe weighs 3,608 lbs.; the victoria 3,498 lbs., and the coupe, with a compartment for baggage, weighs 3,894 lbs.

The two electric motors are of the Krieger type, made by Postel-Vinay. Each has a nominal power of 3 HP., and weighs about 143 lbs. Varying speeds of from 3 to 12 miles per hour are obtained by means of a series-parallel controller. In the trial, speeds of 5.5, 12.3 and 15.9 miles per hour were made on the level with batteries in

series; on a grade of 8.2% the speed was 3.7 miles per hour in series. The total daily expenses of running the three types of Krieger carriages were fixed by the jury at $4.05 to $4.06.

In its general conclusions the jury says that one of the most striking features of this trial was the preponderating influence of the cost of repairs to the accumulators and the pneumatic tires, upon the daily expenses of running electric motor-vehicles. The small quantity of electrical energy consumed on this total course of 347 miles, on some of the most crowded streets of Paris, and the small cost of supplying this energy, was one of the suprises to the jury. In the daily expenses for the Jenatzy, Krieger and Jeantaud motor-car-

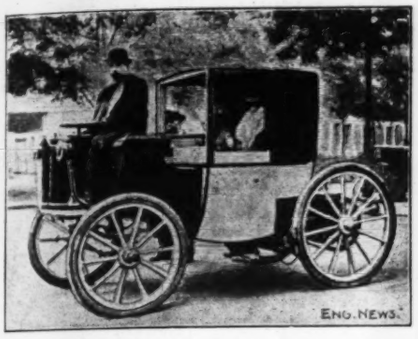


Fig. 4.—Jeantaud Landaulet; accumulator system.

riages the specific energy supplied only cost, on the average, 35.4 cts., 34.8 cts. and 20 cts. respectively. This extremely low cost, says the jury, seems to render it almost practically useless to seek for better methods of utilizing the electric motor in propelling vehicles. But while the consumption of energy has so slight an influence upon the daily cost of operation, the enormous general expenses which swell this cost must not be lost sight of. The electric motor must be designed to reduce to a minimum the consumption of energy on streets with steep gradients, and so regulated and controlled that an inexpert driver can not communicate to the motor currents disastrous to the accumulators.

As to speed, while this was generally satisfactory, the jury hopes that in another year makers will submit motor-cabs which will better meet actual cab practice in Paris, and with as small a consumption of energy as possible, meet the following speed conditions:

4 miles per hour in seeking passengers.

5 miles per hour mounting 5% grades.

7.5 miles per hour on grades from 2.5 to 5%.

9.3 miles per hour as an average in ordinary streets.

12.4 miles per hour in open and uncrowded streets.

Fig. 5.—Krieger Victoria; accumulator system.

At the present time the police regulations of Paris only permit a maximum speed of 7.5 miles per hour in the city streets, and 12.4 miles per hour outside the city walls. The jury contends that the law should be changed so as to authorize a speed of 12.4 miles per hour within the city; if this were done the authorities could be assured that ordinary conditions would prevent a speed much exceeding 7.5 miles per hour in crowded streets. During the motor trial of last June, covering nine days in time and 3,720 miles in distance, the average speed maintained was about 9.3 miles per hour.

The jury says that one of the most difficult things to contend with, in attempting any great speed with motor-carriages on the streets of Paris, is the tendency of the wheels to slip on muddy streets, causing the carriage sometimes to swing clear around. This trouble is aggravated by having the directing wheels in front; and it thinks that some means should be adapted for braking the hind-wheels in case of breakage or damage to the brakes on the front wheels.

THE RELATIVE IMPORTANCE OF FLIES AND WATER SUPPLY IN SPREADING DISEASE.*

The diseases that may be borne in water under some circumstances and by flies under others are typhoid fever, yellow fever, certain forms of dysentery, Asiatic cholera, and perhaps malarial fever, and malarial poisoning in general.

It will be observed that there are two classes of these diseases, the intestinal and the malarial. In the former the infection is a bacillus of some sort, whose presence in any locality can always be traced to some preceding contamination by excretions from a diseased bowel. In the latter the source of infection is a plasmodium, as it is termed, which lives primarily in marshy soil, or stagnant water, and whose presence in that location is independent of contamination from human sources. These distinctions are to be kept in mind constantly in attempting to trace out the manner in which these diseases spread, and in adopting measures for their prevention.

All are most emphatically camp diseases, and hence the propriety of their discussion at a meeting devoted to the subject of "Camp Hygiene." There is the greater need of such discussion because the relative importance of flies and water supply in spreading disease has been greatly misunderstood, especially in the very case of camps where the danger is greatest.

Contrary to ideas that have existed heretofore, in camps and under similar conditions elsewhere, intestinal diseases are spread almost exclusively by flies, and malarial diseases by water. The exceptions to this, which are relatively unimportant, will be noted in the course of the discussion.

In the Cuban campaign last summer it was sought to prevent the spread of diseases of the intestinal class by the use of water from the purest sources, or purified by boiling. It was a failure. Not until late in the summer was the agency of flies taken into the account in any practical way. Even now reports from Honolulu and Manila state that typhoid is still epidemic among the soldiers in those localities, showing that adequate measures of prevention have not yet been perfected. Likewise during the recent British campaign in Fashoda, which was most carefully planned, and which took place in a climate that is exceptionally dry and hygienic, there was no abatement of typhoid fever, it continuing to be the chief scourge of the army.

Nevertheless, diseases of the typhoid type can be prevented with almost absolute certainty, and malarial diseases greatly abated, in both instances by very simple measures. It is only necessary that those most concerned should think it worth while to understand the matter and act accordingly.

It is not possible to enter very much into detail in a brief summary of results such as the present. Suffice it to say that in the performance of his duties as Health Officer and practicing physician, the writer has been able to put an end to epidemics of typhoid fever and dysentery of the exact type that prevail in the army in such manner as to warrant the belief that the problem of their prevention has been solved completely.

For example, the outbreak of malignant dysentery mentioned in my paper at the recent meeting of the American Public Health Association was encountered when at its height, there having been forty cases and ten deaths and the disease spreading rapidly from house to house in a single neighborhood. As soon as measures were adopted such as would make conveyance of the infection by flies impossible, there was not another new case, although there had been fresh ones every day for some time previously. In like manner the past summer a lively epidemic of typhoid fever was ended in a day by measures directed against conveyance by flies. So, too, on the malarial side of the question there has been prevention, without the aid of quinine, by measures directed against conveyance by water.

It is true that under certain circumstances the poison of intestinal diseases may find its way into water and be thus conveyed, and that the poison of malaria may be taken up and carried by mosquitoes or flies, as the case may be. Hence, it is necessary to discriminate carefully in reference to the peculiarities attending these different methods of conveyance of infection.

When flies are responsible there are little neighborhood epidemics extending in short leaps from house to house, without reference to water supply or anything else in common. But when water is at fault the disease follows its use wherever it may go, the only limitation being the resisting power of the individual using it, and such household measures of boiling and the like, as tend to destroy disease germs. Epidemics spread by flies tend to follow the direction of prevailing warm winds, as though the fly, wandering out doors after contact with some source of infection, had drifted with the wind; but nothing of the sort is perceptible in the case of water-borne disease. In villages and camps where shallow open closets are in use, giving access of flies to the chief sources of infection, they are the chief medium of its conveyance. In cities where underground sewers carry such material beyond the ordinary reach of flies, whose migrations are not extensive, such diseases can only become very prevalent through infection of the source of public water supply. Hence in villages and camps they are usually fly-borne and in cities water-borne. When a source of public water supply has been infected in this manner, cases of the disease will occur more or less throughout the year, provided that the germ remains active at all temperatures. When the conveyance is by flies the prevalence of the disease will be confined to a particular season exclusively. Thus in cities typhoid fever prevails at all seasons, in villages it is an autumnal disease. When the weather is dry and sultry flies have their best opportunity to carry the disease, or, in other words, under the very conditions best adapted to prevent its spread if water-borne.

With this understanding of some of the more prominent general relations of the subject, it becomes possible to enter into the study of details that are of the utmost practical importance. For example, in investigating a series of epidemics confined to a single neighborhood recurring year after year, the writer, following the lines that have been indicated, was able to secure very positive evidence, both clinical and microscopical, that burying typhoid material in the ground is no protection against flies. Such a procedure simply establishes a culture bed in which the bacilli, like plants, grow toward the surface, attracted by the warmth and other effects of the sun's rays in that location. If any prevention whatever is secured by such burial of typhoid material without disinfection, it is very transient, especially when the weather is sultry. The application of this to the care of the sinks in the army is evident. Indeed, it is the key to the situation, so far as army conditions are concerned, the danger being greatly intensified by the utter heedlessness of many of the men. Discipline as well as accurate knowledge is required, in order to make preventive measures a success in this case. Indeed, unless carefully looked after, there will be neither burial nor disinfection of such material, far too often.

Furthermore the burial of typhoid material not only fails to prevent the immediate spread of the disease, it on the contrary actually perpetuates it in the locality from year to year. This was clearly shown in the series of epidemics referred to in the preceding paragraph, which came to an end at once when this mode of disposal of material was abandoned, and proper disinfectants were used.

The subject of disinfection in general demands revision from the point of view of the present discussion. The material employed must be suitable. If of a volatile nature like carbolic acid it must be remembered that on evaporation it will leave nothing behind to protect against reinfection, and consequently must be used in large quantities and often, so that not a single particle of material containing living bacilli may escape to re-infect the entire mass. Sulphate of copper in solution, on the other hand, on evaporation, is left behind, diffused through the material, thus prolonging its effect, and even making it permanent, if a sufficient quantity has been employed. Earth containing sulphate of copper thus diffused becomes a good disinfectant, and may be used with confidence to cover typhoid or other infected material.

The time at which disinfection is to be performed is likewise of the utmost importance. If a case of intestinal disease is in progress, the material from the diseased bowel should not be exposed to access of flies without disinfection for a single moment. It is taking serious chances to allow even a single fly to crawl over such material, and then visit articles of food and drink. No matter how cleanly the premises, or what other precautions may be taken, if instant disinfection be neglected, the danger becomes impossible to compute. On the other hand, a very little care at the right time yields a result that is an absolute certainty and that even a child can understand.

Among large bodies of men there will always be some who are negligent, and even among those who are thoughtful, the very beginnings of an attack of sickness may pass unnoticed. Thus there is constant danger that bacilli from the diseased bowel will be planted in the sink and there find opportunity to grow and propagate. Consequently there can be no security unless all excretions are disinfected instantly, if possible. Just here the point that has been made in regard to sulphate of copper in solution as a disinfectant may prove to be the key to the situation. The writer has had large experience with its

*Abstract of a paper read by Dr. M. A. Veeder, of Lyons, N. Y., at a meeting of the Buffalo Sanitary Club, Dec. 14, 1898.

use for this purpose, and has been surprised many times at the way in which even so small a quantity as a pound or two diffused through several barrels of water checked putrefaction and all signs of bacterial growth in foul drains and the like. The fact that soil can be converted into a good disinfectant by its aid is likewise important. It is portable and its color is such that there is no liability of mistake, and it likewise has the advantage of showing visibly exactly how far it has penetrated. It would seem to be the ideal disinfectant for army use, if its efficiency is as great as the writer has been led to suppose. In the absence of water it can also be used dry with good effect, but a larger quantity is required.

If, however, during the exigencies of a campaign no special means whatever of disinfection are at hand, it is nevertheless possible to do much. For instance, it is a good plan to follow the example of the Indians, who change the location of their camps often. Although burying infected material is at best a very uncertain precaution as against conveyance by flies, still it may lessen the chances somewhat for a period of some hours, more or less, according to the quantity or character of the earth employed. Hence it may be resorted to as a temporary expedient, in default of a better, when a camp is to be abandoned very soon, for example, or in the interim between the hours at which disinfectants are to be applied.

If so cumbersome an arrangement as the tank, fourteen feet long and two or three feet square, containing a strong solution of crude carbolic acid, to receive the excretions, as recommended by the commission appointed to investigate the spread of disease in the army, can be had, and its use insisted upon, there is no doubt but that a vast amount of sickness will be prevented. The idea of its use is certainly based upon a correct understanding of the dangers involved, and is something new in army sanitation. Perhaps inventive genius may evolve something even better, and more readily available under all of the exigencies of warfare, now that it is known precisely what it is necessary to accomplish.

Pretty much everything that has been said thus far has had reference to the prevention of conveyance by flies, this being the greatest danger in camps. Still there may be times when the use of water that is liable to contain the bacilli of intestinal diseases cannot be avoided. It may be necessary also to use water from soil in which the plasmodium of malaria is indigenous. In either case boiling is a precaution that has the merit of absolute certainty. If it is possible to make a fire and make a little coffee or tea to drink on the spot, or fill the canteens for subsequent use, it relieves the difficulty completely and at once.

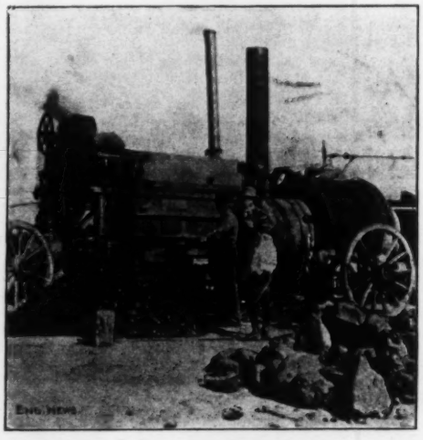
With reference to this mode of escaping malarial disease by not touching water that has not been boiled, the writer has reason to believe that the security it affords is well-nigh absolute. It is possible that there may be some small conveyance by mosquitoes, which are known to harbor the malarial parasites. There is a likelihood also that flies that have come in contact with freshly upturned marshy soil may carry the infection to some extent. But the chances in both these regards are so small that they are nothing compared with drinking the soakage from swamps fairly reeking with the poison. The deepening of wells in marshy soil may be of some assistance, especially if they are of the artesian variety, not admitting water except at the very bottom of an iron pipe. This also avoids contamination with surface filth, and if such water could always be had there would be no need of other precautions. Under army conditions, however, it is better to cultivate the habit of boiling the water as a protection against diseases of the malarial type especially. There are many persons known to the writer who find it cheaper and pleasanter to do this than to dose themselves with quinine while undergoing slow processes of acclimatization, so-called, on any change of residence, for it is a peculiarity of malarial infection that immunity against it in one locality does not always protect in another. Hence there is the greatest need of preventive measures on the part of soldiers, who are liable to be constantly changing their location.

It is evident that much was expected in a sanitary way during the recent campaign against Spain, although it was organized in such haste. The American people do not appear to be willing to tolerate the idea that their boys at the front should be sick at all. At any rate, if there has been suffering and death, they want to know the reason why. It is a healthy symptom. But sanitation under the guns of the enemy is a hard matter, implying thorough knowledge and discipline. If anywhere this should be found, it is on the part of the American soldier who exhibited such magnificent initiative at Santiago. With the tremendous efflorescence of patriotic feeling taking the form of sanitary inquiry in the manner that it has, the Spanish-American war of 1898 may come to be known as the war that saved more lives than it destroyed many thousandfold.

BITUMINOUS ROCK PAVING IN SAN FRANCISCO, CALIFORNIA.

At the present time Market St., the chief thoroughfare of San Francisco, Cal., is being paved with the so-called bituminous rock. We are indebted to **Mr. James M. Owens, B. S.,*** of that city, for the following information concerning this material and its use in California.

Bituminous rock, as found in California, differs from that obtained from Seyssel and Val de Travers in one important particular; it is a bituminous sandstone while the others are bituminous limestones. Stratified deposits of this bituminous sandstone rock are found in a number of localities in California, and also in Kentucky and Utah, though California produces more than 80% of the total yearly output of this material. Probably the best known and most productive mines in California are in Santa Cruz Co.; and the most noted mine in this county is about eight or nine miles from the town of Santa Cruz, N. 76° W., and about 90 miles from San Francisco. It crowns the top of a hill, and is only three miles from the ocean. This mine was first opened in 1864-5, and the material was then distilled to extract the oil. The first shipment of this oil to San Francisco was destroyed by fire when in storage, the project was



Plant for the Reduction of Bituminous Rock by the Hot-Air Process, for Street Paving in San Francisco.

abandoned and the mine remained unworked until early in the 80's. Most of the work in developing the mine has been done since 1885.

This rock is a dark chocolate brown in color, almost black, almost odorless; and in the harder varieties the fracture is irregular, fine-grained and without cleavage planes. At low temperatures it breaks up into fragments like ordinary stone. The rock from the Santa Cruz mine is classified as hard, soft and medium rock; the hard rock, upon analysis, shows a very fine quartz, about as fine as beach sand. The soft rock contains pebbles sometimes ⅛-in. diameter. The Santa Cruz rock carries from 10 to 21% of bitumen and 0.8 to 0.3% of moisture. The specific gravity varies from 1.4 to 1.9. The deposits dip slightly towards the sea, and are from 10 to 30 ft. in thickness, and in most cases are underlaid by a moderately coarse-grained, clean, soft sandstone. The top rock is a very fine-grained, white, clayey sandstone. Numerous fossil remains of marine animals are found imbedded in the rock. The accompanying table contains the results of analyses made from samples of the Santa Cruz rock:

Analyses of Santa Cruz Bituminous Rock.
(Analysis by Thomas Price & Son, San Francisco, Cal., April 28, 1890.)

	Samples	
	No. 1. Soft rock.**	No. 2. Hard rock.†
Asphaltic material	11.50%	16.60%
Silica	86.22%	76.72%
Oxide of iron	1.28%	3.30%
Carbonate of lime	.22%	.38%
Carbonate of magnesia	.18%	2.42%
Water and loss	.60%	.60%
	100.00%	100.00%

**From Walrath Mine Santa Cruz. †Consolidated Bituminous Rock Co.

*643 Haight St., San Francisco.

(Analysis by H. G. Hanks, San Francisco, Sept. 27, 1889.)

	Thurber Hard Rock Mine; Sample No. 3	
	Chemical.	Mechanical.
Bitumen	20.04%	20.04%
Water	.76%	.76%
Silica	57.81%	sand, 79.20%
Carbonate of lime	4.75%	...
Oxide of iron	7.92%	...
Alumina	8.72%	...
Magnesia	Trace.	...

Determination of Asphaltene and Petrolene in Santa Cruz Bituminous Rock.—By Jas. M. Owens, May, 1890.

Chemical Analysis.*

	Samples	
	No. 3.—Medium.	No. 4.—Soft.
Moisture & loss at 86°C.	0.3766⅔%	0.21.5%
Tot'l bitum'n	14.6416⅔% { Pet. 11.773⅓ / Asp. 2.868⅓ }	16.075% { Pet. 13.185 / Asp. 2.89 }
Non.-bit. orgn. matter	.88%	2.42.6
Mineral matter or ash	84.1016⅔%	81.2806%
Specific gravity	1.89	1.45
	100.00%	100.00%

*Samples obtained April 26, 1897, from Thurber Hard Rock Mine and the Walrath Mine.

Residue from No. 3: Sand, consisting mainly of milky-colored quartz; general shade, gray; coarse grained.

Residue from No. 4: Coarser grained sand, contains quartz and golden-colored mica.

Solvents used: Chloroform to extract asphaltene, and acetene to extract petrolene.

High percentage of petrolene noticeable: Over 80% of total bitumen in each case.

Mechanical Analysis.

No. of sample.	Kind of rock.	Per cent. Moisture or loss, 86°C.	Total bit. incldg organic matter.	Mineral matter or ash.	Total.
1.	Medium	0.3983⅓	14.80	84.8011⅔	100.00
2.	Soft	.29	16.2464	83.4644	100.00
3.	Hard	.76166⅔	20.463⅓	78.775	100.00

N. B.—Under the microscope the hard rock shows fine granular structure, and the presence of considerable bitumen. In portions of the soft rock large sized pebbles are quite visible.

Of the several patented processes now employed in San Francisco for reducing this material one of the oldest, and probably the most widely used, makes superheated steam the reducing agent. Disintegration by means of hot air, with petroleum as fuel, is the chief characteristic of the second process; the first method is intermittent and the second continuous. The accompanying cut shows a plant at work by the hot-air process. In the steam process the rock is broken into fragments of about egg-size; is wheeled up an incline and dumped into the kettle through an opening in the top. When filled the lid of the kettle is clamped down and the cooking process is commenced by the use of superheated steam. As the rock is melted it falls into a lower chamber and is removed when disintegration is complete. It is then ready to be taken to the work. Each of these kettles holds about ten tons; and with average rock about 40 minutes are required for complete reduction.

In the hot-air process, the kettle is filled automatically by an endless chain of buckets which deliver their contents into a hopper at the top and rear of the oblong kettle. From the hopper the broken rock finds its way into a revolving cylindrical crib, about 3 ft. diameter and the full length of the kettle; the openings in this crib are about ¼-in. apart, and through these the disintegrated material passes to a chamber below. This chamber has a double jacket of boiler-plate through which hot-air circulates, and this jacket extends up the sides so as to partly envelope the crib. In the bottom of the chamber, and running its full length are two longitudinal screw conveyors, about 12 ins. diameter. These deliver through openings in the end of the kettle. It requires a 7½-HP. engine to operate the mechanism attached to the kettle; and with a fair grade of rock this kettle can turn out enough material to lay about 9,000 sq. ft. of finished roadway, 2½ ins. thick, in one working day. With the so-called hard-rock, this amount is reduced as low as 5,000 sq. ft.

The method usually adapted in laying this pavement is as follows: Bituminous rock disintegrated and hot as it comes from the kettles, is spread over the concrete foundation by means of hot iron rakes. Heated hand-rollers, weighing about 20 lbs. per inch of tread, are then passed over it until a smooth surface is obtained; and while still warm the surface is dusted with infusorial earth which is a powerful absorbent, with the object of

preventing adhesion between the wheels of the roller and the pavement. Finally, a steam-roller, weighing about 300 lbs. per inch of tread, is passed over the pavement, until the wheels of this roller cease to show any indentation. The pavement is then considered fit for traffic.

Since bituminous rock pavement was introduced into San Francisco, about 13 years ago, over 72 miles of pavement have been laid and it is growing in popularity. During the fiscal year ending June 30, 1898, more bituminous rock pavement was laid than in any preceding year, or 74,533 lin. ft.; and this amount exceeds that of any other type of pavement laid in one year since 1893. Macadam is now used in outlying districts only, and cobble pavements are in limited use on steep gradients where smoother pavement would be out of question. The advantages claimed for bituminous pavement are: ease of traction; it is impervious; it is adapted to all kinds of traffic; produces neither dust nor mud, and is easily cleaned; is comparatively noiseless and has considerable elacticity; it is easily laid and repaired and is durable; and on account of its highly granular texture, due to the presence of a large excess of sand, it is not so slippery as asphalt. It is also comparatively cheap; for, in San Francisco, this class of pavement costs from 18 to 28 cts. per sq. ft., or $1.62 to $2.52 per sq. yd., according to difficulties encountered in laying it.

But notwithstanding its many good qualities, bituminous rock pavement has its faults. It is not adapted to grades steeper than 4%; in foggy or damp weather, a thin coating of mud is likely to form on the top of the pavement, if it has not been properly cleaned, and under these conditions the surface becomes slippery for smoothly shod horses. When the pavement has become thoroughly wet, however, this slipperiness is reduced to a minimum. Unless ordinances are enforced regulating the width of tires and the travel upon streets having car-tracks, it is not suitable for constant and heavy traffic, and will wear in ruts. In San Francisco a recently enacted ordinance forbids the driving of any vehicle over a street paved with bituminous rock, and upon which car-tracks are laid, in such a way, that two of the wheels run in the groove of the outer-rail while the other two are running on the pavement proper.

The specifications for the repaving of Market St., San Francisco, with bituminous rock generally provide as follows: The roadway is to be excavated to a depth of 11½ ins. below the finished surface and brought to a true arc with a rise of 1 in. in 3 ft. from the curb to the center of the roadway. After the roadway is properly graded it is thoroughly compacted by a 5-ton steam roller, and all soft places must be dug out and refilled with suitable material, well-puddled with water and re-rolled. On this road-bed will be laid a concrete foundation of 9 ins., made of 1 part Portland cement, 2 parts clean sand and 7 parts clean hard rock, the latter either blue or gray sandstone. Before laying the bituminous rock, the surface of the concrete must be allowed to become thoroughly dry and it must be then broomed and cleaned.

On this foundation the disintegrated bituminous rock is to be spread in equal parts of soft and pulverized hard rock thoroughly mixed. The mixture must contain 12 to 15% of natural bitumen; must be of even texture; free from quartz, sulphates, clay, gravel or other impurities. This mixture shall then be heated in a suitable closed kettle, adjacent to the work, to about 215° F., by a process whereby neither wet nor dry steam, nor flames of eny description, nor the direct heat from flames, shall be allowed to come into direct contact with the mixture. The heated rock is applied in a layer 2½ ins. thick, as before described.

A SECTIONAL DUMP CAR.

In most of the large dump cars now used for ballasting, filling, and other railway and construction work, provision is made for regulating the operation of dumping, so as to deposit the material in any desired quantity, at any particular point. This is usually effected by means of the doors through which the material is discharged, but in the Page car, which we illustrate this week, it is effected by mounting a series of dumping boxes on the car frame.

The Page car is made in two styles: The side-sill car has six boxes (three on each side) which discharge the load on opposite sides of the track; the center-sill car has three boxes (each the full width of the car), which can discharge their load on either side. In the side-sill car, the boxes are pivoted nearly over the sills, while in the center-sill car they are pivoted over the center sill. The builders consider that the center-sill type is in general preferable, since it enables the entire load to be dumped on either side of the car.

The accompanying cuts represent a car of this latter type. The underframe consists of five longitudinal sills, two end sills, and two intermediate cross sills, with transverse tie-rods, the whole frame being stiffened by four truss rods. On the end and cross sills are erected frames which support the dumping mechanism, latches, etc. The three dumping boxes are all the same size, and are pivoted on a steel T-bar over the center sill, the bar extending the full length of each box and being bolted to the bottom of the box. The boxes rest and rock upon flat iron straps on the upper face of the center sill. A malleable iron extension of the T-bar enters a cast socket which is secured to the end and cross sills, to hold the boxes in position over the sill. To avoid heavy framing in the ends of the boxes they are not built with a view to sustaining the pressure of the load unaided, but are reinforced by the vertical frames, which are provided with anti-friction rollers, engaging with bearing points on the boxes.

The sides of the boxes are closed by doors which hook on to lugs on the ends near their upper edges, and are secured at the bottom by straps entering keepers on the side sills of the boxes. Their action is automatic. As the boxes tip, projections on the doors first drop into seats on the caps of the frames, to prevent further downward movement. They are then released from the box and hang swinging. Latches pivoted to the vertical frames engage lugs at the four upper corners of the boxes. When returned to position the boxes are automatically locked.

Sheet steel shields, hinged to the outer ends of the vertical frames, cover the latches and the frames, and serve to prevent material from falling between the boxes and dropping on the ends of the latches. They also prevent the raising and releasing of the boxes. The hinges of these shields are provided with safety hooks, which engage the boxes, so that each box is thus secured with four latches. Buttons are placed on the middle frames, where the ends of the shields meet, and these may be turned so as to prevent the raising of the shields. A spring on the bottom shaft maintains a pressure so as to prevent the button from being turned by anything but a special wrench. This wrench is intended to be kept only at the unloading point, insuring against the boxes being dumped anywhere else, since none of the boxes can be dumped unless the shields are raised.

On construction work where many men are employed, the boxes may be tipped by a direct lift, and sometimes by means of cant hook levers. If, in loading the car, care is taken to trim the load, it is only necessary to raise the latches, whereupon the boxes dump automatically. Under favorable conditions one crew of men has unloaded and restored the boxes of a car for loading in one minute. Where a large number of men are not at hand, a dumping device may be employed, by which two men, standing on top of the vertical frames, one at each end of the box, can tip the boxes to either side of the car. The dumping device consists of a malleable iron casting, so constructed as to admit of attaching it to the box end at its highest point. The casting projects over a rack on the vertical frame, and is provided with pawls which drop into the rack. An opening in the casting admits of the insertion of a lever, which is used in moving the casting over the rack. The rack is used as a fulcrum of the lever, the pawls dropping into the indents of the rack and holding whatever is gained by each lift of the lever. With one of these devices at each end of the box it may be tilted to any angle desired and kept from tipping back.

The door opening of these boxes is large enough to allow a 3-ft. cube to pass out. When occasion demands, the doors can be removed and the car used as a flat car. The floors being horizontal the car is available for a great variety of freight service, whether it is desired to dump the load or not. It is claimed that the car can be used for hauling such materials as earth, sand, ore, coal, ballast, building stone, pig-iron, cinders, etc., which can be discharged by dumping or shoveling, or by means of a derrick. One of the special advantages claimed is that a sticky or frozen load will be discharged more readily from a tipping box than from a car having a stationary inclined floor.

A number of these cars are in use on the Chicago, Lake Shore & Eastern Ry. They are 36 ft. long, with a carrying capacity of 60,000 lbs. and a bulk capacity of 42 cu. yds., and are mounted on ordinary diamond frame freight car trucks. The floor, which is covered with 3-16-in. steel, is 4 ft. 8 ins. above the rails, and the top of the side is 8 ft. 2 ins. above the rails. The cars are fitted with air brakes and automatic couplers.

Fig. 1.—Page Sectional Dump Car in Running Position.

Fig. 2.—Page Car, With Two Boxes Dumped and the Third Ready for Dumping.

THE PAGE SECTIONAL DUMP CAR AS USED ON THE CHICAGO, LAKE SHORE & EASTERN RY.
The Sheffield Car Co., Three Rivers, Mich.

Some of them were built by the Pullman Car Co., of Chicago, and others by the United States Car Co., of Hegewisch, Ill. Mr. W. G. Brimson, President of the railway company, informs us that the cars were built for the purpose of ballasting and filling trestles. Since that work has been finished they have been used successfully for about two years in the coal and ore traffic, with practically no cost for maintenance. These cars are of the center-sill type.

Fig. 1 shows one of the cars in its normal running position, and Fig. 2 shows the same car with one box dumped to the right, another dumped to the left and the third ready for dumping.

These cars were invented and patented by Mr. C. D. Page, of Greeley, Colo., who is now in Seattle, Wash., building some cars of this type for the White Pass & Yukon Ry., of Alaska. The new cars are 36 ins. gage, 3 ft. 6 ins. long. Each car carries two boxes, the inside length of which is 13 ft. 3½ ins. They are to be used on construction for hauling ballast, railway ties and other building material. Later on they will be put into coal service.

For information respecting these cars we are indebted to the Sheffield Car Co., Three Rivers, Mich., which is interested with Mr. Page in the patents.

FIREPROOF FLOOR SYSTEMS USED IN LONDON.*

By Frederic R. Farrow.†

In the earliest forms of fireproof floors used in London, the aim of the inventors seems to have been simply to provide a floor of non-combustible material, and for a very long time the importance of preventing damage to the incombustible components of fire-resisting floors was wholly neglected; but, at the present day, it is almost needless to point out that it is quite as important that the construction of a fireproof floor should be such as to obviate the possibility, or at least the probability, of damage occurring to the building by failure of the floor in several other directions besides that of combustibility. A fireproof floor to be of any reliable value must not permit of any part of its construction being melted, distorted, or broken by the action of the heat of the fire, or by the water used in quenching the fire, nor must there be any possibility of damage by expansion or contraction of the various constituents of the construction under the greatest extremes of heat and cold to which it may be exposed.

The importance of avoiding damage by expansion and contraction militates against the employment of some otherwise admirable materials. It also renders it imperative that all metal work shall be preserved, not only from the direct action of fire, but also from the convection of any considerable amount of heat by such protective sheathing as may be incorporated in the construction of the floor.

Perhaps the earliest attempt at the construction of fireproof floors was the employment of a series of iron girders supporting brick arches which rested upon the upper surface of the flanges. In some of the very earliest examples, the girders were of cast-iron, but the system was continued subsequently with rolled iron joists. Those who used this form of floor evidently felt that there might be some possibility of trouble arising from the thrust of the arches, and therefore in some cases wrought-iron tie-rods were inserted below the level of the brick arches. The result could hardly be otherwise than disastrous: the girders and tie-rods were exposed to the full action of both fire and water, and the failure of one girder meant, of course, that of the arches supported by it, which necessarily would be speedily followed by the collapse of the whole floor from the thrust of the remaining arches. Such an unsatisfactory method of construction may now, we hope, be relegated to the limbo of forgotten ineffectiveness. The use of unprotected iron girders for supporting incombustible construction of various kinds remained, however, the common practice for a very long time; and although suggestions were made for adequate protection of the iron many years ago, it is but quite recently that this has been generally regarded as a sine quâ non in the design of a satisfactory fireproof floor.

The varied forms of fireproof floors which have been devised may be classified into those which do not attempt complete protection of the ironwork, those which do attempt complete protection of the ironwork, and those in which endeavors are made to dispense with ironwork, or, at least, iron joists altogether. In each of these classes we have a subdivision into those forms of construction which require temporary centering, and those which provide their own centering, or have a permanent centering.

There are but few examples now in use of fireproof floors which do not attempt some protection of the ironwork, although in several instances the protection consists only of a suspended ceiling. Fireproof floors, in which a permanent centering is used are constructed with curved sheets of corrugated galvanized iron resting upon the upper surfaces of the lower flanges of the iron joists with concrete filling-in above this centering.

Messrs. William Lindsay & Co.'s floor, shown in Fig. 1, of steel decking with concrete filling-in above, is a floor designed with the view of weight-bearing capability. The under surface of the steel decking and the lower flanges of the joists are unprotected. The concrete used is pumice concrete, that is, it is composed of coke breeze, sand and Portland cement. Where protection to the iron is desired a suspended ceiling can be applied as shown.

Passing on to the consideration of those floors which attempt complete protection of the ironwork, and taking first of all those which require temporary centering, we have a group in which the ironwork is wholly embedded in solid concrete. Of these, Lindsay's system with interlaced tension rods passing over and under the iron or steel joists is illustrated in Fig. 2. The concrete is in this case pumice concrete.

Messrs. B. Ward & Co. have constructed floors under their patent for a steel webbed solid concrete floor, in which the steel webbing passes over the top of the iron joists, and so is embedded in the lower half of the thickness of the concrete. This was one of the earliest forms of floor in which the idea of increasing the tensile strength of concrete by means of embedded metal was adopted. Messrs. W. B. Wilkinson & Co. have also made floors of solid concrete with the joists embedded and the tension iron rods passing over the top of the joist.

The Stuart Granolithic Stone Co. make thin floors in granolithic concrete, with the steel joists embedded in concrete blocks, and using central beams also of granolithic concrete, as shown in Fig. 3. Floors in granolithic concrete have also been constructed in arched form with thin crowns and thickened haunches.

Another group of floors is that in which flat arches between the joists are used, provision being made for the protection of the under side of the joists on which the arches rest. Of constructions of this kind we have examples in the Doulton-Peto floor, illustrated in Fig. 4, in which the arches are built of fire-clay blocks with dovetailed sinkings on the sides to form a key for the cement. Another example is Messrs. Blanchard's floor, in which perforated blocks are used, tied together with iron rods passing through the joists, as shown in Fig. 5. Similar in principle to these are Burnett's floor, Hornblower's, and Northcroft's; whilst Whitcord's system, with solid fire-clay blocks enclosing the lower part of the joists and forming the skewbacks of the arches, may be taken as the parent of these systems of construction.

The United Terra Cotta Co. use arched forms in flat arches similar in principle to those already described in the Doulton-Peto, and cognate systems. The essential feature is that the material of which the hollow blocks are composed is a very light and porous earthenware, obtained by mixing the clay with sawdust before burning.

The more modern examples in this section are to be found in a group of which Banks' floor and the floors made by the Expanded Metal Co. are the best illustrations. In Banks' fireproof floor the steel joists are wholly embedded in the concrete, excepting the under side of the lower flanges, and these are protected by the suspended ceiling hung from the top of the steel joists. This floor is shown in Fig. 6, with the wood centering in position, for the removal of which the hangers to the ceiling are hinged.

The Expanded Metal Co. use their patented material as the basis of several varying forms of fireproof floors. The expanded metal lathing is generally embedded in the lower part of a concrete slab to which it therefore imparts, as do other arrangements of embedded metal, the tensile strength in which simple concrete is deficient. In most of the methods adopted by this company, the concrete slab with the embedded metal lathing is above the joists (as shown in Fig. 7), which are protected by being embedded in concrete, cased around with metal lathing and plastered or shielded by a suspended ceiling. In other instances the joists are themselves embedded in the concrete slab, the metal lathing being placed either below or between the joists. Additional strength for the concrete slab is in some cases provided by arched ribs of channel iron and concrete, either with or without a suspended ceiling.

The hanging arrangement for the suspended ceiling is shown in Fig. 8, the wire lathing being attached to the thin bars by the clips shown. An example of a floor with the joist cased is shown in Fig. 9.

Of floors in which a permanent centering is provided or of which the construction of the floor is independent of any temporary centering, there are a large number of examples that attempt complete protection of the iron or steel joists. In the majority of these floors the lintel principle is adopted in construction rather than the arcuate.

Of these the Fawcett floor is a typical example, the special feature being that the hollow tubular earthenware lintels are arranged diagonally, their own diagonals being at right angles to the line of the joists. The advantage sought by this method is to enable the lintel to cover more completely the under-side of the lower flange of the joist. These tubular lintels form the centering for the concrete which is filled in above as shown in Fig. 10.

Messrs. C. G. Picking & Co.'s interlocking floor is similar in some respects to the Fawcett, but each lintel has two tubes, and projections are arranged at the side to afford the means of interlocking. This is shown in Figs. 11 and 12.

The Shepwood patent floor is an arrangement of flat terra cotta slabs grooved at the edges and fitted to the flanges of small T-iron bearers, which span the distance between the joists. Special blocks are made to cover the lower flanges of the joists and thus a complete permanent centering for the concrete is formed.

In the most modern type of Messrs Homan & Rodger's floor, triangular lintels are used, passing from joist to joist and resting on the lower flange, the under surface of which they cover. This form is illustrated in Fig. 13, whilst an older type is shown in Figs. 14 and 15.

Messrs. Aston & Son construct a floor, which as will be seen from the illustrations, Figs. 16 and 17, is a combination of flat lintels of T-section and corrugated iron permanent centering. This floor was formerly carried out by

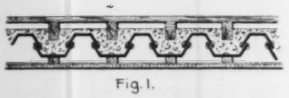


Fig. 1.

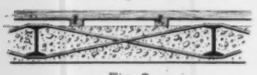


Fig. 2.

Fig. 3.

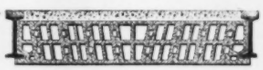


Fig. 4.

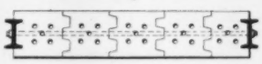


Fig. 5.

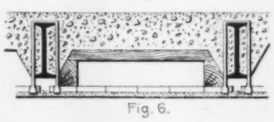


Fig. 6.

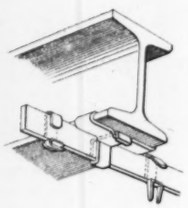


Fig. 8.

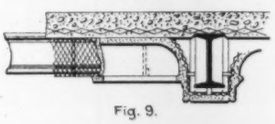


Fig. 9.

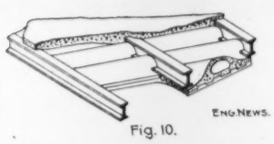


Fig. 10.

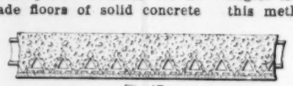


Fig. 13.

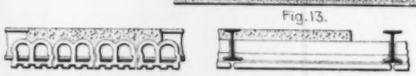


Fig. 11. Fig. 12.

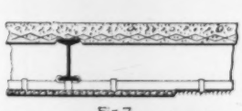


Fig. 7.

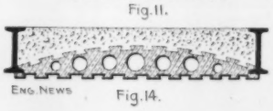


Fig. 14.

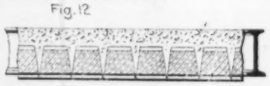


Fig. 15.

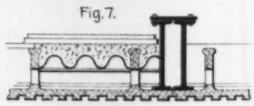


Fig. 16.

*Abstract of paper presented to the British Fire Prevention Committee.

†7 New Court, Lincoln's Inn, London.

Willis & Astley, the preceding holders of the patent. Messrs. Aston & Son also construct floors of solid concrete with terra cotta casings to flanges, as shown in Fig. 18. This latter form of floor, of course, requires temporary centering.

Messrs. Potter & Co.'s floor, as illustrated in Fig. 19, is a combination of several ideas. The lower flanges of the joists are protected by clay shields which support corrugated iron permanent centering for the concrete, and in addition there is a suspended ceiling of wire lathing and plaster.

Another example of the lintel system is the Adamant Cement Co.'s floor, in which the lintels are formed of concrete blocks composed of Adamant cement with breeze or other aggregate, and sometimes strengthened by the insertion of steel laths. On these lintels is laid a concrete filling. The lintels are slightly varied in form, one shape being shown in Fig. 20, and another in Figs. 21 and 23.

Approximating somewhat to the lintel form are the floors known as the Mulciber and the Carlisle. The former of these, as will be seen from Fig. 23, consists of loose fireclay blocks, enclosing the flanges of the joists and forming corbels, on which rest the hollow fireclay lintels, serving as the permanent centering for a slight finish of concrete. The Carlisle consists of two hollow tubes between each pair of joists, and the filling in of concrete, of which there is a very small amount, forms the key between the tubes. This is illustrated in Fig. 24. A somewhat similar floor to the Carlisle has been made by Messrs. Picking & Co., as shown in Fig. 25.

In Messrs. B. Ward & Co.'s system of cellular tubes between the joists, as illustrated in Figs. 26, 27 and 28, the especial feature is that the cellular slabs or lintels are formed of gypsum, this being in small pieces.

For domestic buildings and where no great weight is to be carried by the floors, or where the floors are of small spans, various forms of fireproof floors are in use which are specially intended to fulfil these particular conditions. As examples of these we have concrete slabs with expanded metal or other lathing, Edwards' floor of concrete slab with iron rods, and several other similar constructions. There is also the method of using wood beams set diagonally so as to form skewbacks for the reception of concrete arches or slabs.

A method of considerable antiquity, but now very little used, is that in which a floor sometimes flat but more often arched in section, is constructed of plain roofing tiles, and in three or four courses laid in cement and breaking joint, with or without a finish of fine concrete on top. This method has been largely used for corridors and other situations where the floors are of no very great span.

Fireproof floors formed of wood have been introduced, such as Evans & Swain's, which consists of ordinary wooden joists nailed together side by side, thus forming a practically solid floor of wood.

A newly patented floor is Hinton & Day's, in which the space between ordinary floor joists is blocked in solid with wood at the lower part of the depth of the joists. A layer of concrete is sometimes added.

Another class of floors intended to provide a moderate amount of protection or "fire-resistance," includes those in which the ordinary construction of wood-joisted floor is supplemented by pugging on fibrous plaster slabs as carried out by Messrs. Wilkinson, or pugging laid on metal lathing without rough boarding and nailed to the under side of the wood joists. A modified form of Messrs. Ward's cellular gypsum slabs, already referred to above, has been used for affording protection to the under side of an ordinary wooden joisted floor. The protection of ordinary wooden joisted floors is carried out also by various combinations of special fire-resisting plasters, and various forms of special lathing.

Amongst these special plasters may be mentioned Asbestic, Fibrous, Silicate Cotton plaster; Adamant cement, and Robinson's cement. Amongst the special Lathings may be mentioned the Expanded Metal already referred to, and Banks' Helical Lathing, in which flat ribbons are interlaced in lattice fashion but twisted between their interlacings. Jhilmil is a metal lathing in which flat sheets of metal are cut and bent up and down to form projecting strips, thus forming a metal lathing with space for keying. There is also a fire-resisting lathing recently introduced by the Mural & Decoration Syndicate, made of woven iron wire studded at its intersections with terra cotta.

Mention must be made of concretes of special composition for the purpose of resisting fire more thoroughly than ordinary concrete. One of the first introductions of this nature was the gypsum concrete of Messrs. Dennett and Ingle. A more recent introduction is the Boyd-Wilson patent concrete, in which "Kieselguhr" is used on account of its low conductivity.

Fig. 17.

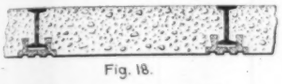


Fig. 18.

Fig. 19.

Fig. 20.

Fig. 21.

Fig. 22.

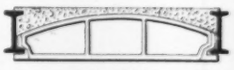


Fig. 23.

Fig. 24.

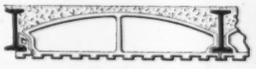


Fig. 25.

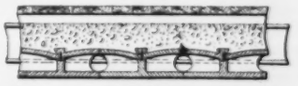


Fig. 26.

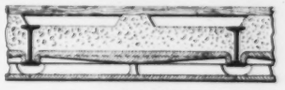


Fig. 27.

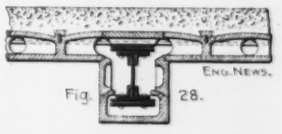


Fig. 28.

RIBBED GLASS AND THE DIFFUSION OF LIGHT THROUGH WINDOWS.

Previous to 1883, Mr. Edward Atkinson, President of the Boston Manufacturers' Mutual Fire Insurance Co., began to study the best means of diffusing light through windows and skylights in mills, factory buildings, etc.; and in the year named he submitted a report to the Cotton Manufacturers' Association, together with a suggestion for fixed light and transom windows which has since been widely adopted in mill practice. The windows recommended had no sliding sash and were glazed with thick, rough plate glass. This glass cost more than common glass; but it was less liable to breakage; the sash cost less; the thick glass retained the heat in winter, and the light, though a little less, was much better diffused and no shades were required to keep out the glare of the sun.

About the same time he experimented with various forms of glass for this purpose, including prismatic, corrugated, rough, waved and ribbed glass. He had photographic images taken from each kind, and also from plain glass; and he found that the greatest and most uniform diffusion of light was not derived from prismatic or from angular forms, but from simple ribbed glass in true curves, inverse and obverse, 21 ribs to the inch. This form of glass was fortunately in commercial use for certain purposes, and was also the cheapest type of glass suitable for glazing windows, except the common clear glass. There are no patents on the ribbed glass itself, and it was introduced into mills with very satisfactory results. It soon became evident, however, that more complete research was necessary, and the investigation was placed in charge of Mr. C. L. Norton, of the Institute of Technology. The conclusions reached by Mr. Norton were published about three years ago in Circular 67 of the company; but as many new facts have developed since then, Mr. Norton was commissioned to make a second and still more complete investigation, and this report is now made public in Circular 72 of the Boston Manufacturers' Mutual Fire Insurance Co., which is given briefly as follows:

Mr. Norton started out by decidedly doubting the assertion made, that more light was admitted into a room when glazed with corrugated glass than when glazed with plain glass. But experience has clearly shown that at the rear wall of a room 25 ft. deep the intensity of the light was increased three times by substituting ribbed glass for plain. A similar increase is found on the side walls and ceilings, but on the floor there is a distinct loss near the window. Mr. Norton explains this effect as follows:

> The light entering a room through a window comes, for the most part, from the sky, and has, therefore, a general downward direction, varying with the time and position. Hence the position of the room which receives the most light, ordinarily, is the floor near the windows. But, of we interpose in this downward beam of light a dispersive glass, the light no longer falls to the floor, but is spread out in a broad, divergent beam, falling with nearly equal intensity on walls, ceiling, and floor. We must bear in mind that we gain nothing in the total amount of light entering the room, but we have simply redistributed the light, taking up from the floor that which fell there and was comparatively useless, and sending it in directions where it is of more service. The result of the examination of the various glasses was to show that a finely ribbed or corrugated glass was better than the others, as it gives the widest and most unform distribution. There is no apparent gain in corrugating both sides. Ground glass is barred out, because of its actual loss of transparency, caused by slight amounts of moisture or dust. The ribbed glass about 3-16-in. thick, with 21 ribs to the inch, known now as "factory ribbed glass," is, says Mr. Norton, the best dispersive glass upon the market. When a glass of slightly better appearance is desired, that which is known to the trade as "maze" glass is the best. It is similar to the fine ribbed glass, except that the ribs are not straight, but are bent into irregular figures.

Photometric measurements were made by taking two rooms, one above the other, alike in exposure, shape and size, and comparing the intensity of light falling on similar portions of the two, when one was glazed with plain glass and the other with the glass under examination. Broadly speaking, it was found that the center of the room was as bright when lighted by a window of 1 sq. ft. of ribbed glass as with a window of 3 sq. ft. of plain glass. This was true in all lights; from a bright sunshine to a heavy thunderstorm, and with the windows facing in any direction.

The circular reproduces a number of photographs of the same rooms or objects taken when lighted by plain and by ribbed glass. In each case the greater intensity of light derived from the window glazed with ribbed glass is very apparent. One of the most striking of these exhibits is a pair made by exposing a photographic plate in the bottom of a box, in the cover of which was a round hole, provided with a shutter. One opening was filled with plain, and the other with ribbed glass. When exposed a second or two and developed, the plate back of the plain glass showed a perfectly round, bright spot, proving that the light came straight through the hole; on the plate exposed to the ribbed glass the light was diffused over a large surface without clearly defined margins. As the plate was only 6 ins. from the hole the angle of dispersion in the latter case was found to be nearly 90°.

Mr. Norton says that this ribbed glass is especially useful in the factory, where the question of position of machinery, etc., is usually decided by convenience in setting it up, and the possibility of getting the greatest number of operatives into the smallest possible space. If the man near the window needs a shade he cuts off light from the entire room; but the substitution of ribbed for plain glass does away with the necessity for the shade and benefits, instead of harming, those remote from the window. In the school-room, this soft, even light, leaves no desk or book untouched, and is a great protection to the eyes; its use in laboratories, in libraries, and in art galleries, is also commended.

Factory ribbed glass is best set with the ribs running vertically; as otherwise, when the sunlight strikes it, it is too dazzling for comfort. But it may be used with horizontal ribs in basement and cellar windows, where the brightness of the glass does not matter. In these latter places the full measure of the gain in the use of ribbed glass is best appreciated. The fact that operatives in a mill cannot attend to affairs in the street is an advantage; though it is seriously objected to by the operatives themselves, and Mr. Atkinson suggests that it might be well to have some plain glass in each window on this account. But the

real gain to the operatives is the better diffusion of light and the protection from the glare of objects outside; shadows are also less sharp. The ribbed glass also diffuses heat; and while the temperature of the whole room is not changed, the heat from the sun is spread evenly over the whole room, instead of being uncomfortably concentrated on a spot near the window.

The ribbed glass should have its ribs on the inside, for ease in keeping it clean; and where double glass is used the ribs should be crossed and set facing each other. Ribbed glass is made with a wire netting imbedded in it, and it has the same optical characteristics as the ordinary ribbed glass.

Mr. Atkinson, in commenting on this report, says that he finds that the use of ribbed glass on the south side of a mill, subject to full exposure to the sun, does not abate the need of shades in many places. He hopes that a glass may yet be found which will shut out part of the light and diffuse that admitted. Another caution is that in mills, print works, or other places devoted to color work, only the pure white glass should be selected. Many kinds of glass that appear pure white show a distinct greenish tinge, if examined on the edges; and the slightest tint of green destroys all possibility of discrimination in many colors. Mr. Atkinson considers that where windows of the ordinary kind have been bricked up, or guarded with shutters, on account of fire hazard, wire-glass of the "maze" pattern would help to stop the spread of fire and at the same time greatly improve the light. Glass of this latter kind is made by the Mississippi Glass Co., with an agency at 20 Canal St., Boston, Mass.

THE NEW BREAKER AT CRANBERRY COAL MINE, HAZLETON, PA.*

By W. S. Ayres, M. Am. Inst. M. E., Hazleton, Pa.

(With two-page plate.)

The construction of a new breaker at the Cranberry Colliery, Hazleton, Pa., was forced upon the operators, A. Pardee & Co., by a fire which destroyed the entire plant early in January, 1896. The loss included, in addition to the breaker, three boiler-houses and three engine-houses. The breaker-engine and all the machinery in the breaker, including the rolls, screens, jigs, etc., were a total wreck.

Among the things aimed at, in the design of the new breaker which was made and carried out by the writer, were:

1. An arrangement and style of machinery that would be very simple, and enable the coal, as it comes from the mine and is hoisted to the top of the breaker, to descend by gravity through the various rolls, screens and jigs to the storage-pockets without the use of any elevator or device for rehandling. Also, such designs of crushing-rolls as would produce a larger percentage of the larger sizes of coal, and a correspondingly smaller percentage of the smaller sizes, than had been obtained in the old breaker. The special relative arrangement of the dump, rolls, screens and jigs, as adopted, is the conception of Mr. F. Pardee, the Superintendent.

2. The introduction of easy grades and turns in all the chutes that convey the coal from one machine to another and to the pockets, so as to avoid chipping and waste.

3. A design of frame for the breaker that would be very rigid, and at the same time use the smallest amount of material for the strength and rigidity required, and that would also embody the possibility of taking out any piece and replacing it, as, for instance, in repairs.

The detailed description of the breaker now to be given will follow, not the above order, which is the logical order controlling the design, but the successive steps of construction, namely: (1) Foundations; (2) frame of structure; (3) machinery; (4) chutes and connections; to which will be added (5) a statement of results.

Foundations.

The foundations were built of stone laid in cement, one foundation for each post, having a broad base and tapering to a capstone about 2 ft. square. There are, in all, 131 of these pyramidal foundations. The size of the base was determined in each case by the nature of the soil and the load that would come upon the post. A careful calculation was made of the load that would come upon each, comprising the weight of the structure, machinery, coal going through and stored in it, the water in jigs, and the effect of vibrations, wind and snow. Fig. 1 is a plan of the foundations.

Fortunately, the majority of the foundations under the breaker proper, including all those carrying the greater weights and subject to the greater vibrations, were upon rock. Where they came upon clay and hard-pan, one to two tons pressure per square foot was allowed, and the size of the base for each was figured from the weight to be carried by that post.

These foundations were not less than 4 ft. deep, so as to ensure them against frost. Yet at this shallow depth, the pressure per square foot assumed for each was far less than the greatest intensity consistent with the stability of the earth. To allow fully for the vibrations that would be caused by the machinery, when in motion, an intensity of pressure was assumed, representing about half that allowable for the same depth were the structure to remain in absolute repose.

The cement used was the Hudson River Rosendale, mixed one of cement to two of sand. The stone used was a very hard conglomerate, having a probable safe working resistance to crushing of at least 50 tons per sq. ft., this being one-tenth of its probable ultimate strength. To avoid any settling, a bed of about 2 ins. of sand was first put into each pit, and the first course of stone was well rammed into it. Large flat stones were selected for this course. In each successive course great care was taken that each stone should be well bedded upon the one below. Only the hammer was used, however, in dressing, so that stone touched stone with only enough cement between to fill up the irregularities of the bedding-faces and abutting joints. This precaution was necessary, as the cement has a safe working strength of only 3 to 5 tons per sq. ft., while the stone, even though it touches the one under it on only a few small surfaces, has a capacity to resist 500 tons per sq. ft. before crushing. That is to say, in all foundations carrying as much as 125 tons, the small surfaces of contact together must equal an area not less than ¼ sq. ft.

This area is quite easily secured in ordinary hammer-dressing, and, when reinforced by the resistance of the cement, the foundation can be relied upon.

The cap-stones were from 20 to 24 ins. square by 12 to 15 ins. thick, rough-chiseled to a level surface on top, after bedding. The above method was adopted in the construction of the foundations, as giving the least risk of settling, the least mason-work, the least cement, and the least labor.

Frame of Structure.

The old breaker, which was consumed by fire, had been constructed entirely of timber, and according to the old plan for wooden structures, which has been in general use in the anthracite region since the mines were first opened, fifty years ago. It consisted of solid members, braced with the usual short braces, framed together in the usual way with mortises and tenons, and pinned with 1¼-in. wooden pins. All upright pieces were set upon, and mortised into sills, which rested upon long stone-wall foundations. The old structure contained about 1,300,000 ft., B. M., of lumber.

The defects developed in the old structure were:

1. The foundations would settle directly under the posts for want of a base of sufficient size at these points, while between posts the foundations were unaffected and useless.

2. The sill-timbers would crush and rot, and the posts would also rot, causing a very great settling, which, added to the settling of the foundations, would throw the machinery all out of line. This was a very serious matter.

3. The mortises and tenons, particularly those of the braces, formed pockets for water to lodge in. When the pin or tenon was rotted off, only the boxing prevented the timber from falling out.

4. It was impossible, except at relatively great expense, to replace any timber or brace framed with mortise and tenon.

5. In the solid members, such as posts, ties, inter-ties, etc., the centre or heart of the stick was found in many cases to be entirely rotten, even to within an inch or less of the sides.

There was a want of rigidity in the structure, due to the short corner-braces, and to the tendency of those pieces acting as struts to shove apart the joints between ties and posts.

7. The strength of any post depended entirely upon what was left of its cross-section after cutting the mortise.

To meet the evils above enumerated, to avoid the use of large and long timbers, which are becoming more scarce and expensive every year, and to use the timber in its most efficient directions, was the problem; and it was solved in the following manner:

The first of the above evils was met by building an individual foundation for each post, with a base sufficiently large to resist the pressure without settling, as described above under the head of "Foundations."

The second was avoided by not using sills under any part of the structure; and the considerations which suggested remedies for this and for the third, fourth, fifth, sixth and seventh defects, were based upon well-known facts concerning the strength of timber, namely:

(a) The ultimate resistance to crushing of white pine, for example, across the grain, is only about 550 lbs. per sq. in.

(b) The ultimate resistance to crushing in the direction of the grain, or end-wise, is about 5,500 lbs. per sq. in.

(c) The ultimate tensile strength in the direction of the grain, or end-wise, is about 11,000 lbs. per sq. in.

(d) A hollow column is stronger than a solid one of the same cross-sectional area of material; the strength increasing as the hollow space increases.

Other kinds of timber, such as oak, yellow pine, hemlock, etc., have ultimate strengths differing from those of white pine, but they follow the same general law.

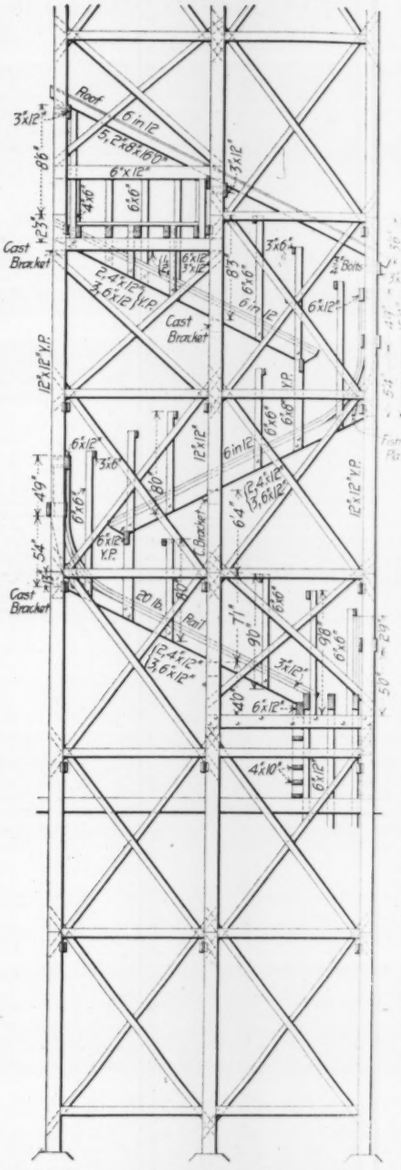


Fig. 6.—Detail of Rock Chute Between Bents 17 and 18.

In view of these facts and deductions, it was decided:

1. Not to place any timber in such a position that it would be acted upon by the load across the grain either in compression or tension, except when this was absolutely necessary, as in the case of bearers under tracks and machinery.

2. To make all braces, as far as possible, act in tension.

3. To build up the posts from ordinary commercial sizes and lengths of lumber, such as can be found in almost any lumber-yard, and to make them hollow.

These points decided, the next step was to design and arrange the machinery in such relative positions, without any reference to the frame, as would accomplish in the best manner the preparation and handling of the coal. Two thousand tons per day of 10 hours was the capacity aimed at.

This done, an outline-design of the structure, having a total height of 200 ft., was sketched about the machinery. Then a very careful calculation, which covered about 100 pages, was made to determine the strain in each piece of the entire structure. This calculation embraced the weight of each machine, the coal running through it, the water in the jigs, all connections, platforms and enclosures, the weight of the roof and snow, the strains due to the wind, and the weight of each piece of timber that entered into the structure. The calculations of the wind-strains in

*Condensed from a paper read at the Atlantic City meeting of the American Institute of Mining Engineers. We are indebted to the courtesy of the Institute for the privilege of reproducing direct several of the cuts accompanying the paper.

this high structure were complicated, and in some members showed a possible strain of 27.5 tons to be provided against, assuming a wind-velocity of 80 miles per hour.

After the general outlines of the frame and its bracing were sketched around the machinery so as to accommodate every convenience of operation, strain-sheets were constructed from the calculations, and the timbers were assigned to resist the various forces, according to the well-known principles above stated. The result of this by no means trifling labor is shown in the elevation and section of the breaker, Figs. 2 and 3.

The size of each post and strut was determined by Gordon's formula, using a factor of safety of 10, and that of each tie and brace by using one-tenth of the ultimate tensile strength as the safe working-load. To the net sectional area so determined was added whatever would be cut away by the bolt-holes, bolts being used throughout to connect all joints. The number and size of bolts required for each joint was determined by dividing the total strain on the member in consideration by the load one bolt would carry, this load being found by multiplying together the thickness of the timber, the diameter of the bolt and the safe working-pressure per square inch for the timber used. Those timbers which would receive severe shocks (as in the dump, under the rolls, etc.), were increased in size to at least twice the strength required for a quiescent load.

From the elevation shown in Fig. 2, it will be observed that the structure is in two principal divisions; bents 1 to 17 inclusive forming the plane, while bents 18 to 22 inclusive form the breaker proper.

The plane has three tracks with room for the fourth. Each bent is framed as shown in the section through bent No. 8, shown on the left of Fig. 2. The questions of rigidity and of stability against wind-pressure were the most important in designing the plane. To make the structure with sufficient width of base to resist the wind-pressure would require a base so wide that it would occupy valuable ground desired for other purposes. At the same time, the tops of the high bents would have an unavoidable sway, which increases, as shown by experience, the longer the structure is in use. The simple narrow-base parallel bent, shown in Fig. 2, with guy-lines to meet both the sway and the wind-strains, was decided upon. The higher bents were provided with two sets of guy-lines one set attached about 70 ft. from the ground and the other at the top. The wind-strains on these guy-lines, with the wind at 80 miles per hour, is estimated to be 10 tons on each. These guy-lines were grouped in twos and fours at the anchors, which consisted of old railroad-rails, bent like the letter A, with a hook turned on the lower end of each leg, into which was laid a piece of old shafting, and, across the shafting, pieces of old mine-rails. On top of the rails flat stones and pieces of slate from the mines were laid to a depth of 1 foot; and then the earth from the pit was thrown in. Each pit was made large enough so that the weight of earth on top of the anchor would exceed the combined pulls of the guy-lines attached to that anchor. A screw-device for adjustment was attached to each guy-line, and formed the connection with the anchor. These guy-lines are of 1¼-in. and 1½-in. galvanized steel, and were finally adjusted so that the deflection taken out of them by a wind having a velocity of 80 miles per hour, would not allow the structure, when struck by such a hurricane, to sway more than ¼-in. at the height of 165 ft. A hurricane having a 60-mile gait did strike it, July 27, 1896, but without producing any appreciable sway.

The posts of the plane are made of two pieces separated 6 ins., and are butt-jointed every 14 ft. These two pieces are 3×10 ins. for bents 1 to 9 inclusive; 4×10 ins. for bents 10 and 11, and 4×12 ins. for bents 12 to 17 inclusive.

The cross-diagonal braces are 3×6 ins. in size, and are entered between the post-pieces, as shown in the elevation of bent No. 8 on Fig. 2. The longitudinal diagonal braces are 2×6 ins. in size. Owing to the slender proportions of these braces they will practically act only in tension, a condition which, coupled with the arrangements of the braces at the joint, will pull the joints together, and never tend to separate them. This completely removes the objectional features of the short brace, and at the same time makes each panel a rigid frame, which the short brace cannot accomplish.

The cross-ties and inter-ties are made of two 2×8-in. pieces, separated by fillers and joint-pieces. In the cross-ties they are separated 6 ins. throughout, while in the inter-ties they are separated 4 ins. at the center and only 2 ins. at each end.

The mode of framing employed by the contractor was to lay each bent upon skids, placing the various posts, cross-ties and cross-diagonal braces in their exact positions, sawing the post and cross-tie-pieces to a given length, sizing the post-pieces, where the cross-ties came against them, to a uniform distance from the center line of the post, and then laying the whole on the skids, and boring through for the bolts. Next, all bolts were put in, except those, the omission of which would permit the bent to be taken apart in sections for erection.

The plane just described practically continues beyond bent 17, and on top of the breaker proper, from bents 18 to 21 inclusive. The highest part, between bents 20 and 21, carries the three main sheaves for the hoisting ropes. The strain coming upon these three sheaves, amounting to more than 30 tons, is carried directly to the foundations by two struts fastened to the outside of the posts, as shown in Fig. 2. In like manner the main counter-shaft is provided with a vertical strut to resist the jar of the bevel-gears, and with one running diagonally to the engine-foundation, to resist the weight of the shaft, its equipment, and the pull on the driving-ropes, together amounting to 8 tons; also with three horizontal struts, forming the bearers for the counter-shaft, and abutting against the three rows of steel columns in the breaker, to resist the pull on the driving-ropes running from the counter-shaft to the rolls. The object of these devices was to carry the ever-varying and intense strains produced at these working-points directly to the foundations; and the wisdom of it has been shown by the fact that the structure is entirely free from any racking strains or vibrations.

All pieces are of easy access for repairs. For example, to replace any section of a post, the entire weight coming on that post can be taken off by simply slacking the guy-line on that side and tightening the one on the opposite side; and then, by removing a few bolts, the piece is easily removed.

The breaker proper was framed in the same general style as the plane, although some modifications of the cross-ties, inter-ties and bracing were found necessary about the machinery. The majority of the posts are made of two 6×12-in. pieces of yellow pine, separated 4 ins. The cross-ties and inter-ties are made of two 4×12-in. pieces, separated 4 ins. The fish-pieces, in the cross-ties which come directly opposite each other, run between the post-pieces, and, as one piece, hold the ends of the opposite cross-ties against the post. In cross-ties not opposite, the fish-piece stops at the opposite edge of the post. The inter-ties, all of which come against the side of the 6×12-in. post pieces, are cut square and between the posts, and are carried by a cast bracket which forms the connection with the post.

On posts 18, 19, 20 and 21, C. D. and E, the load to be carried is so great that a compact post 2 ft. square would be required for each. A compact or solid post 2 ft. square was out of the question. Therefore, for these twelve posts, steel columns of the Carnegie 12-in. Z-bar type were substituted. These twelve columns carry the greater part of the machinery, and are braced with diagonal braces. They extend from the foundations to the crusher-rolls, and vary in length from 118 to 126 ft. While they cost erected about 1¾ times the cost of the equivalent wooden posts, yet they have the advantage of greater rigidity and greater durability, in addition to occupying much less valuable space.

The framing of the coal-pockets, eleven in number, for receiving the seven different sizes of prepared coal, each having a capacity of 100 tons, is such that they rest on posts entirely independent of the posts of the breaker. This was done chiefly to avoid adding these 1,100 tons to the already great load of the breaker, and secondly, because it was far easier to provide for their support by using independent posts, giving at the same time far greater advantage for repairs.

A view of the breaker in process of erection is shown in Fig. 4, and a view as completed in Fig. 5.

Machinery.

All coal is hoisted to the top of the breaker direct from the bottom of the mine in 2-ton mine-cars, and is there dumped into a dump holding 25 car-loads. This storage capacity is to insure a regular supply of coal for the breaker against any irregularity in the hoisting. From this dump the coal passes over bars, to sift out the fine coal, and the larger pieces are fed into the crusher-rolls by a regulating feed, or, if lump-coal is to be made, another set of bars is put in over the rolls, and the suitable lumps of clear coal are pulled aside and passed to the lump-coal chute, all other pieces being passed into the crusher-rolls. Just below these rolls the crushed coal and that coming from the bars are mixed, and the mixed product is divided into two equal streams, one going to the prepared-rolls of the east side of the breaker and one to those of the west side; or the whole product can be turned to either set, as desired.

From this point down, the breaker is divided into two distinct parts, exactly alike, each a complete breaker within itself. This is to enable work to continue in one-half of the breaker if a break-down should occur in the other half, or, in running on half-time, to run half of the breaker all of the time.

The product from each set of prepared-rolls is again divided immediately under the rolls, half going to a complete set of screens on the north side and half to a complete set on the south side. At this point, therefore, when both sides are running, the total product is divided into four equal parts, two parts from each set of prepared rolls. Each of these four parts passes directly into a screen, the "over"-product of which is steamboat and broken sizes. The steamboat-size passes to a picking-space and then to the egg-rolls. The broken size passes to a jig, then to a picking-space, and then to either the pocket for that size, or, if not wanted in the market, to the egg-rolls, where, together with the steamboat-size, it is broken down to egg and smaller sizes, which are separated by a special screen, the "over"-products of which are egg, stove, chestnut and pea, all of which pass directly to the pockets without jigging. The "through"-product from this screen passes to a buckwheat- and No. 2 buckwheat-screen, which sizes pass directly to the pockets or to the boiler-house.

At the picking-spaces of the steamboat- and broken-coal the "bony" coal, consisting of pieces that are part slate and part coal, is picked out and passed to a set of bone-rolls. There is one set of bone-rolls and one set of egg-rolls for each side of the breaker. The product from these bone-rolls is divided and passes into the chestnut-screens.

Returning now to the "through"-product of the steamboat and broken-screen, it will be followed to the pockets. It is at once passed to a second screen, the "over"-products of which are egg and stove, which pass to jigs, then to picking-spaces, and then to the pockets. The "through"-product of this egg- and stove-screen passes to a third screen, the "over"-products of which are chestnut and pea, which pass to jigs and then directly to the pockets. The "through"-product of the chestnut- and pea-screen passes to a fourth screen, the "over"-products of which are buckwheat and No. 2 buckwheat, which pass directly to the pockets or to the boiler-house. The "through"-product of the buckwheat- and No. 2 buckwheat-screen passes to the settling-tanks, with the "wash-water."

From the pockets the prepared coal is drawn into cars for shipment. The pockets, eleven in all, have a storage-capacity of 100 tons each, to insure the running of the breaker against any shortage in cars.

The coal, from the time it is dumped from the mine-cars at the top of the breaker until it reaches the cars for shipment, is made to pass from one process to the next by gravity only, no elevators being used. To accomplish this it was necessary to build the structure to the unprecedented and apparently dangerous height of 200 ft.—apparently dangerous because of the wind-pressure and the constant vibrations from the heavy machinery placed so high above the ground.

The capacity of this machinery is 2,000 or more tons of merchantable coal per day of ten hours.

A brief summary of all the machines is as follows, viz.:

Rolls.—1 pair crusher-rolls, 36×72-in. shell, fitted with 286 steel teeth in each roll; 2 pairs prepared-rolls, 24×48-in. shell, fitted with 280 steel teeth in each roll; 2 pairs egg-rolls, 24×36-in. shell, fitted with 520 steel teeth in each roll; 2 pairs bone-rolls, 24×36-in. shell, fitted with 2,700 steel teeth in each roll.

Screens.—All screens are of the revolving type.

Four steamboat- and broken-screens, 12 ft. long, with two rings of segments, one 5 ft. in diameter and the other 7 ft.; 4 egg- and stove-screens, of the same dimensions; 4 chestnut- and pea-screens, of the same dimensions; 6 buckwheat- and No. 2 buckwheat-screens, of the same dimensions; 2 egg-, stove-, chestnut- and pea-screens, 18 ft. long, with three rings of segments, 5, 7, and 9 ft. in diameter.

Jigs.—Four broken-coal, 4 egg-coal, 4 stove-coal, 4 chestnut-coal, and 2 pea-coal jigs.

Before passing to the description of the individual machines, a glance at the dump at the top of the breaker, shown in elevation on Fig. 2, may be of interest. In order to hoist to the dump, in 2-ton mine-cars, coal to the amount of 2,000 tons per day, it is necessary to hoist three cars at a time. The cars are hitched together with extra long chains, and the three tracks over the dump are arranged so that the cars, when in position to dump, stand as shown on Fig. 2, thus making room for the coal

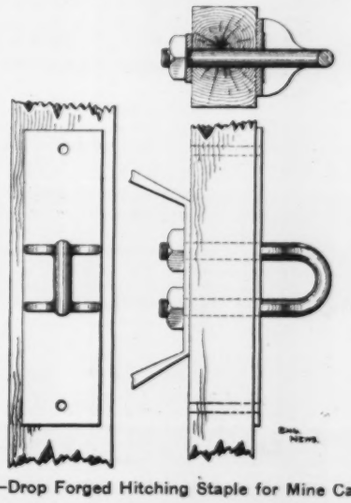


Fig. 7.—Drop Forged Hitching Staple for Mine Cars.

dumped from a car above to drop into the dump without striking the car below or lodging on its bumpers. In hoisting three cars at a time, it will be plainly seen that there is three times the pull on the hitching-staple at the upper end of the upper car that would occur in hoisting only one car. This triple strain is increased as the cars are pulled over the corrugated track of the dump, and it

acts in an oblique direction on this staple, alternately up and down, causing a bending-action that would be sure to break the ordinary staple, and cause serious run-aways. Those between the cars are acted upon obliquely also, but with less strain. This danger was anticipated and forestalled by replacing the old staples with new drop-forged steel staples, designed by the writer, having brace-wings, as shown in Fig. 7.

Of the machines, the rolls and jigs play the most important part. The rolls were increased both in diameter and length over those ordinarily in use, and the teeth were made with the points hooked forward in the direction of the motion. The section of the tooth is like the area included between the segments of two overlapping circles. This forms a tooth with rounded sides and cutting edges. The tooth also tapers to a point which looks forward. The rolls of the larger diameter produce a smaller percentage of the small sizes of coal. This is due to the piece of coal being acted upon by the teeth in a way that approximately splits it into pieces. In the old small-diameter rolls, the piece of coal rides on the teeth and is abraded by them before it is pierced and carried through.

The screens are of the revolving type, having a greatly increased screening surface. Eighteen of these are double, having an inner circle of segments 5 ft. in diameter and an outer one of 7 ft.; and all are 12 ft. long. The remaining two have a third circle of segments added, 9 ft. in diameter, and the 5-ft. circle is extended 6 ft., making a total length of 18 ft. for the 5-ft. circle and 12 ft. for the other two.

The jigs are of a special design, patented by Mr. F. Pardee. They are driven by small engines, one for each jig. There are 18 of these jigs in the entire breaker, and, when running full, 2,000 tons of coal per day of ten hours can be prepared with them.

The entire machinery of the breaker is driven by a 30 × 48-in. non-condensing engine.

The transmission of power from the engine to the counter-shaft, and from the counter-shaft to the various rolls, is by a manila rope-drive. From the engine to the counter-shaft ten 1½-in. ropes are used; from the counter-shaft to the crusher-rolls, four 1½-in. ropes; from the counter-shaft to the prepared-rolls, two 1½-in. ropes, and from the counter-shaft to the bone-rolls, two 1½-in. ropes. The egg-rolls are driven by gears from the bone-roll shaft. This arangement of the rope-drive is shown in elevation by Fig. 2.

The entire counter-shaft, and, in fact, the entire rope-drive, except the main driving-sheave at the engine and the sheaves at the rolls, is out of doors, and without any protection from the weather. The weather seems to have some effect upon the ropes to tighten them in wet weather and to make them more slack in dry weather, but the range of this change is not sufficient to give any trouble, provided the ropes are adjusted to the right tension when dry. The first set of ropes was put on in September, 1896, including only five ropes on the main drive from the engine to the counter-shaft, and also only those from the counter to the east-side machinery of the breaker. On July 1, 1897, the west-side was put in operation, and the remaining ropes were put on. All of these ropes are still in operation without renewal.

Many interesting problems were discussed in connection with the selection of a means of transmission of the power of the engine. The counter-shaft is about 85 ft. above the engine-shaft, and so nearly directly over it that it was impossible to count upon any grip on the pulley or sheaves being furnished by the weight of the slack-side of either a belt, a wire rope, or a hemp rope. Therefore, it was necessary to adopt some convenient way to take up all slack and insure a perfect grip.

A leather belt was discarded, because it would be very difficult to keep it at the proper tension without a tightening-pulley, which is a very objectionable device, and also because it would require housing, besides costing about five times as much as a manila rope-drive. A wire rope was found to be uncertain in its grip on the sheaves, and its life could not be warranted. To secure the required grip, a continuous-rope wound system would be required, with a take-up for wear and stretch, which in turn would require some system of differentiation in the grooves of the drum, like the Walker differential drum, to prevent one round of the rope from running away from the others and doing all the work or breaking, a result which may follow a very slight difference in the diameter of the grooves or of the rope. A wire rope-drive was, therefore, out of the question, because of its complications, uncertainty and cost. In like manner the manila continuous-rope wound system was considered and discarded, in view of the objection that if the rope should part for any reason the whole system would be unwound and serious delays would occur in rewinding it.

In the manila individual rope-system were found the advantages of a very low first cost, non-requirement of housing, and ability, if one rope should part, to continue work at once with the remaining ropes. The question of differentiation in the grooves in the manila rope-drive, although the necessity of it exists, is not as serious a problem as in the wire rope-drive, owing to the greater elasticity of the manila rope and to the V-shape of the grooves used. Yet the question arose, how would a new rope work with an old one that is much reduced in diameter by wear? Would the V-shaped groove accommodate this great difference in the diameter of the ropes? It was feared not. The difficulty was solved, however, by the adoption of a shackle and coupling-link like that used by the Philadelphia & Reading Coal & Iron Co., at its storage-docks at Schuylkill Haven, Pa. This shackle is of the ordinary U-shape, is made very short, and has the legs flattened into very thin plates, so as not to increase the diameter of the rope very much. A shackle is riveted on each end of the rope, and the two are hooked together by an open link. This slightly increased diameter at the shackle lifts the rope out of the groove a little as it passes over each sheave, enabling the rope to yield a little toward the side that is drawn too tight. This solved the difficulty of differentiation entirely.

The ropes are shortened, as wear and stretch make it necessary, in two ways. One is to unhook the coupling-link and put more twist in the rope, and the other is to cut off a piece of the rope at one end, and replace the shackle. This is done in the noon-hour, or after-time, but is not a matter of very frequent occurrence after a new rope has received its permanent set. The number of ropes necessary to drive the rolls was doubled, to provide against any delays from the parting of a rope. On the main drive several were added for the same reason.

The diameter of the sheave on the engine-shaft is 20 ft., with 10 grooves in its 22-in. face. On the counter-shaft the main sheave is 10 ft. in diameter, while all others are 6 ft. The speed of the engine ranges from 50 to 60 revolutions per minute, as desired. The speeds of the ropes on the main sheave, corresponding to these speeds of engine, are 3,100 to 3,800 ft. per minute. The screen counter-shaft is driven from the main counter-shaft by bevel-gears, and in turn drives the eighteen 12-ft. screens by means of link-belts. These link-belts have a speed varying with that of the engine from 470 to 565 ft. per minute, and work exceptionally well as a drive in a dusty, dirty place.

Chutes and Connections.

Owing to the great height of the breaker, it was necessary to resort to some special and unusual device for delivering the slate and rock, and some of the coal, from points high up in the breaker to the loading tracks below. Among these will be mentioned only the device in the rock-chute between bents 17 and 18, the spiral chutes from the jigs to the pockets and the spiral lump-coal chute.

The usual way of delivering the waste and the coal to the loading-tracks has been by long, straight chutes, down which the slate or coal runs, at times with a cannon-ball velocity. Turns have frequently been introduced, so as to avoid certain spaces or to gain more distance in which to accomplish the descent. This system requires a great deal of lumber, and occupies a great deal of valuable space, besides having the objection as to the coal-chutes, of chipping the coal badly at every turn, and also where it drops into the pocket. These chippings are small in size and worthless, but their constant production, even in small quantities, reduces in a year, by many tons, the output of the larger sizes of coal, which are most valuable. In the slate- and rock-chutes, however, no such considerations arise, and they usually take the shortest route. One necessity, however, does arise, namely, to provide against the impact of the large pieces at the turns or at the draw. This is usually done by making the timbers at the turns very heavy.

On Fig. 2, in the rock dump, where it turns at the top of bent 12, is shown the device used to avoid the full impact of the large pieces, or of a car-load of mixed sizes, dumped suddenly and moving as one mass. Each car of rock dumped into this chute weighs approximately from 3 to 3½ tons. This device consists of a vertical return, in which the material dumped on the upper section is delivered at an oblique angle against the curved end of the lower section. The force of the impact in this device is only about two-thirds of that produced when the piece is brought against the turn at a right angle. On account of this condition, less timber was used to provide against impact.

This rock-chute down to bent 17 is perfectly straight, but between bents 17 and 18 it makes two horizontal and two vertical turns. These are shown on Fig. 6. The bottom of the chute at each turn is completely covered with 20-lb. rails, laid with the heads up, as in a track, and as close together as the bottom flanges will permit. They are slotted in the flanges, and fastened down with bolts. Such a bottom presents a series of rail-heads to receive the wear, and they are separated about 1¼ to 1½ ins.

When a piece of rock slides down the long, straight part of the chute and enters the horizontal turn it strikes the heads of these rails a glancing blow across their length, and the greater part of its force is expended in passing from rail to rail. Thus the full force of impact is avoided in the horizontal turns. At the lower part of the chute, where the rock and slate are drawn into the dump-cars, there is another horizontal turn, constructed in the same manner. Between these two horizontal turns will be seen, on Fig. 6, two vertical turns which operate in the same manner as the one in the dump at the top of bent 12, above described. Thus a drop of 82 ft. is made in a horizontal distance of 72 ft., and without any destructive shocks.

From the jigs to the pockets, the vertical drop ranges from 70 ft. from the broken-coal jigs to 34 ft. from the pea-coal jig. To convey the coal from the jigs by the usual inclined troughs, or "telegraphs" (a good name for this trough, for the coal often goes through it at almost lightning-speed), would require many thousand feet of lumber, besides which the building would need to be increased by about one-half of its present floor-space to accommodate them. About a mile of these "telegraphs" would have been required. After discussing this method, together with several modifications of it, the possibilities of a spiral chute, or, more correctly speaking, a helicoidal chute, were brought forward and carefully gone over, with the result that, after some hesitation, they were adopted. To determine the correct pitch, so that the coal would neither stop nor run too fast in the chute, was a problem concerning which there were no practical data to be found. From the experience with quarter-turns, both in the old breaker, and also in other breakers in this region, it was decided to adopt a pitch of 3¼ ins. per ft. for the outside circle.

A chute was then constructed as follows:

The outside diameter is 36 ins. and the inside diameter 16 ins. The cross-section is uniform for all sizes of coal from broken to No. 2 buckwheat, the width being 16 ins., and the heights of the sides or flanges 4 ins. for the outside and 2½ ins. for the inside. The chute is made of cast-iron, with four segments to the circle. They are also made rights and lefts. Each segment is provided with four holes in its outer flanges, two at each end, and all are countersunk on the inner side, and are large enough to take an ordinary ¾-in. chute-nail. These segments, or spiral chute-plates, are nailed between four upright posts of yellow pine, each 4 × 6 ins., and each plate joins the next one at the center of a post. No support is used for the inside edge of the plates. The surface of each plate is made to match that of the one below by a beveled joint, so made that the plate above rests on the one below.

The floor-space occupied by these chutes is very small, being only about 3 ft. square for each chute, and no difficulty occurred in finding space for them.

In the practical operation of this chute it was found that the pitch was not great enough for the smaller sizes of coal, and that the chutes would choke. This was remedied by taking the plates out, and nailing them in again in a tilted position, which gave them more pitch. Since this change, no difficulty has been experienced.

When the machinery was put into the west side of the breaker, from April to June, 1897, a new set of chutes was made, having a different pitch for each size of coal, as determined by the experience on the east side. Only the pitch was changed; all other dimensions were retained.

Between a jig and the place selected for its spiral to go down, a connecting-chute is made of these spiral plates by using alternately a right and left segment. They are nailed to a 12-in. plank that has been stiffened by a backing-piece, 6 ins. wide, set edgewise and spiked to its under side. These right and left plates form a zigzag chute, through which the coal passes without any acceleration. When the coal enters the spiral it at once crowds against the outside flange, and the pieces tend to arrange themselves in a tandem order, forming, particularly in the larger sizes, a continuous stream of single pieces of coal. When the speed increases above a certain amount, each piece leaves the bottom of the plate and runs against the outside flange, where it assumes a uniform speed which is regulated by the centrifugal force pressing it against the side and causing greater or less friction, according to the tendency of the piece to accelerate or retard.

In the pockets the spirals run to the lowest points desired, so that all the coal will be delivered into them without any drop or impact. They are made without any inside flange, and the action of the coal is to slide off the inside edge of the spiral at the immediate surface of the conical mass that is accumulating in the pocket, and to slide down and over its surface. No impact of any consequence occurs from the time the coal leaves the jig until it is at rest in the pocket, and the amount of chippings, therefore, is very small. It is fascinating to see the coal en route to the pockets. First it goes like a snake and then it takes a spin.

The lump coal chute, which begins at the bars over the crusher-rolls, makes a drop of 110 ft. in 78 ft. horizontal. This chute has two sections which are also constructed as spirals. It is shown, in elevation and detail, on Fig. 3, at the right or east side. The same want of data as to pitch, confronted us in the construction of this chute, as in the construction of those just described. It should be clearly understood that the pitch of a spiral does not follow the same law as that of a straight chute. Under these circumstances, and in the anxiety to avoid, particularly in this chute, the usual cannon-ball velocity, the same error was made as to the pitch, that was made in the others. The pitch proved to be not quite great enough. It has not yet been changed to a greater pitch, because lump-coal is not in demand, and, therefore, is not now made. There is no doubt, however, that it will work.

Results.

Foundations.—The foundations are carrying their respective loads without any settling. This is due to the fact that the intensities of pressure assumed to be safely carried by their various parts, are, in practice, within the limits consistent with the stability of the earth upon which

they rest, and of the safe working-pressures for the stone and cement used.

Frame of Structure.—In the plane,the advantages gained by the use of the open-member, narrow-base construction, stayed with guy-lines, are briefly as follows:

1. The narrow-base avoids occupying valuable room wanted for other purposes, that would be fully occupied by any self-sustaining broad-base construction.

2. The guy-lines hold the top of the structure perfectly rigid, while in any self-sustaining structure the sway will increase with use.

3. The open members have all the advantages over the solid members, which have already been mentioned in the description of the frame. Prominent among them are:

(a) Greater rigidity of the frame.

(b) The commercial sizes of timber used are cheaper and always obtainable in emergency.

(c) They are more easily inspected.

(d) They will season better and dry out quicker after being wet, and therefore are less liable to rot.

(e) Each piece is easily removed and replaced in repairing.

(f) The open-work in the columns, ties, and cross-ties, and the use of braces acting in tension only, consumes generally about two-thirds of the lumber, for the same strength, that is required by the solid-member construction.

In the plane as constructed, about 127,000 ft. of lumber were used, 24,329 lbs. of bolts and washers, and 5,972 ft. of 1⅛, 1 3-16, and 1¼-in. guy lines.

The saving in lumber as compared with a broad-base self-sustaining structure, built after the same open-member system, is about 100,000 ft.; and, as compared with a broad-base solid member system, is about 200,000 ft. The value of this timber at $25 per thousand, erected, is $5,000. Against this must be charged the guy-lines and their connections (about $800), and the bolts and washers (about $550), or $1,350 in all, leaving as a net saving to the credit of the method used, $3,650, in the plane alone.

In the breaker a similar saving of about 250,000 ft. was effected, which, added to that saved in the plane, makes a total saved in the entire structure of 450,000 ft. of timber. The value of this 250,000 ft. at $30 per thousand, erected, is $7,500, against which must be charged 45,951 lbs. of bolts and washers (about $1,100), leaving, as a net saving, in the breaker, $6,400. This, added to the saving in the plane, gives as the total net saving in the entire structure, to the credit of the method used, $10,050.

The old breaker, which was a smaller structure, contained over 1,300,000 ft. B. M., and the new one just described contains about 900,000 ft., including the equivalent of the steel columns and exclusive of the trestles to the slate-banks.

The contract was awarded to S. D. Kingsley, of Olyphant, Pa., and the entire erection was performed without an accident of any kind. The number of skilled carpenters required was comparatively small. Instead of an army of skilled carpenters at work making mortises and tenons, only a few skilled men were required to direct the assembling of the pieces, to lay off their proper distances, and to mark the positions of the bolt-holes. All of the contractors bidding on the framing and erection were very wary, and even fearful that the structure would not stand up. In fact, some were very pronounced in their disapproval of it. But such views are not now entertained.

Machinery, Chutes and Connections.—All that will be necessary to give here as to the efficiency of the machinery, chutes and connections will be the approximate gain effected by making a greater percentage of the larger sizes of coal and a correspondingly smaller percentage of the smaller sizes. Compared with the old breaker, it is estimated that from 10,000 to 20,000 tons, on a yearly out-put of 300,000 tons, is transferred from pea, buckwheat and No 2 buckwheat to egg, stove and chestnut.

In this comparison it is also necessary to bear in mind that egg, stove and chestnut are the sizes that command the highest prices in the market, while pea, buckwheat and No. 2 buckwheat command the lowest, and lump, steamboat and broken the medium prices. The above gain is accomplished by the style of the rolls, the simplicity of the machinery, the absence of all elevators, and the avoidance, by the use of the spiral chutes, of any impact. The item of saving in labor in the cost of preparation should here be mentioned, as it also stands to the credit of the construction of the breaker, and of the efficiency of the machinery. In the old breaker, to prepare 1,150 tons per day, 194 men and boys, on an average, were required. In the new breaker, to prepare 2,000 or more tons per day, only 84 on an average are required. Mr. Pardee has recently made some important changes in his jig that will in all probability reduce the number of slate-pickers from 55 to not more than 25, and they will be employed only on coal that is not jigged. This will further reduce the total number of men required from 84 to 54.

As to the capacity of the breaker, it has been intimated, under the head of "Machinery," that more than 2,000 tons of merchantable coal could be prepared in a day of ten hours. All calculations and expectations in this direction have been more than realized, and it is now assured that 3,000 tons can be prepared instead of 2,000.

The tendency in the preparation of anthracite coal has been, in recent years, to complicate rather than simplify the process, particularly since the late Eckley B. Coxe read before the Institute his famous paper on the "Iron Breaker at Drifton," in which he described so many ingenious refinements in coal-preparing machinery. In the construction of the Cranberry breaker the greatest simplicity was aimed at, so as to avoid the frequent handling and consequent undue chipping of the coal, the costly repairs on complicated and expensive machinery, and, not least of all, to do the work of preparation with a far smaller number of men.

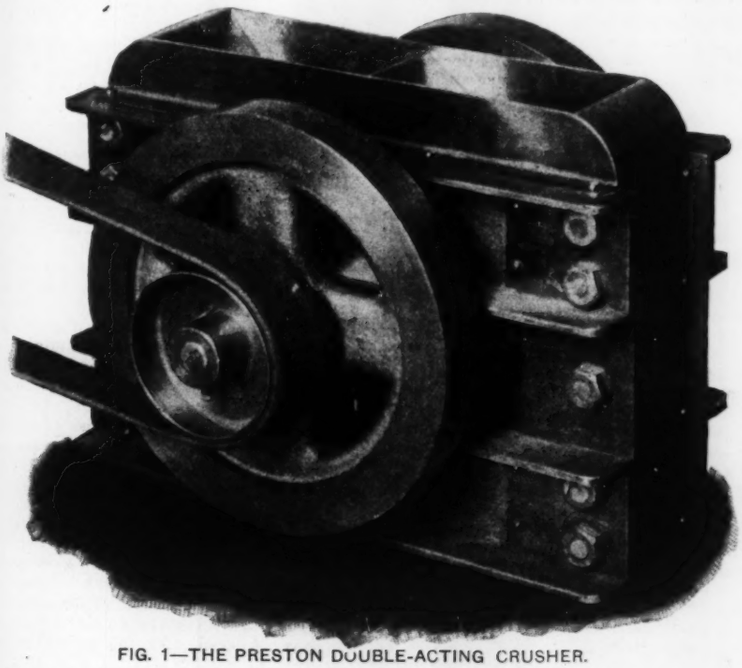
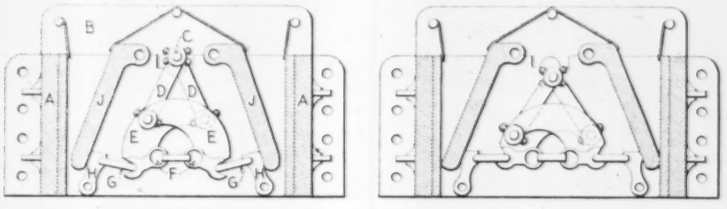


FIG. 1—THE PRESTON DOUBLE-ACTING CRUSHER.
J. C. McEvoy & Co., Beloit, Wis., Builders.

A DOUBLE-ACTING STONE CRUSHER.

In most crushing machines of the jaw or reciprocating type, the crushing is done by a single jaw, but the Preston crusher, which we illustrate herewith, is a double-acting machine, having two sets of jaws at opposite ends of the frame. A general view of the machine is given in Fig. 1, while Fig. 2 shows a sectional view with the jaws open.



Jaws Open. Jaws Closed.

FIG. 2.—LONGITUDINAL SECTION OF PRESTON DOUBLE-ACTING CRUSHER, WITH JAWS OPEN.

The cast-steel frames, A, are surmounted by a hopper, B, and the crankshaft, C, runs across the tops of the frames. This shaft carries two arms, D, D, to which are attched the levers, E, E, turning in fulcrums, F, F, which are journaled in the frames. In the ends of the levers are inserted the toggles, G, G, which, by means of the pivoted push-plates, H, H, operate the steel crushing jaws, J, J. Great crushing power is claimed for this combination of toggle, lever and crank, and the cranks are so arranged that one jaw is always one-sixth of a stroke ahead of the other.

Lightness and strength are obtained by the use of cast and forged steel for all parts except the two fly-wheels and the belt pulley. In order to fit the machine for transportation in difficult country, for mining and other purposes, it is built up in sections, no part weighing more than 400 lbs., and in case of wear or breakage new parts can easily be applied.

The machine is intended for work in mining districts and for crushing stone for ballasting, macadamizing and other purposes. It is also said to be equally effective for cement and emery works. It may be mounted on wrought-iron trucks if desired, so as to be readily portable. In a test made at the builders' works, a machine having two 12-in. jaws and driven by a 5-HP. motor, readily crushed what are termed "hard-heads" or "iron stone," 7 to 9 ins. diameter, to a 1-in. size, both jaws crushing at the same time.

This crusher was invented by Mr. F. L. Preston, of Beloit, Wis., and is being manufactured by J. C. McEvoy & Co., of Beloit, Wis., to whom we are indebted for blue prints and other information.

A NEW APPLICATION OF THE POETSCH PROCESS, for shaft-sinking by freezing, is proposed for a deep shaft at Harchies, Belgium. The strata overlying the coal measures are 745 ft. deep. The first 170 ft. is made up of dry strata, of blue marl, etc., and the remaining 570 ft. is sand heavily charged with water; the trial borings giving rise to an artesian well discharging nearly 23,000 gallons per hour, and rising 16 ft. above the surface. The engineer proposes to form an ice-wall by freezing from the outside; but as the freezing tubes might be crushed flat and circulation prevented by the enormous pressure developed in the lower strata, he proposes to keep the central boring open down to the coal. The top would be closed and provided with a stand-pipe rising to a height equal to the hydrostatic head at the surface; then, any excess pressure due to increase of volume by freezing would be relieved by the surplus water flowing out at the surface. To prevent the freezing of the pipes in the upper dry strata, he would lead steam or hot water through a ½-in. pipe placed in the central boring and going down to the bottom of the marl deposit. In this method the amount of water flowing from the relief-pipe would be a good indicator of the progress of the freezing process.

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We give considerable space in this issue to a description of a coal breaker recently erected at Hazleton, Pa., which embodies some novel features in construction and in its arrangement of the machinery for handling the coal. The most notable is the use of guy lines for securing the structure against wind-strains instead of giving its posts a batter, according to the usual practice.

The use of guy lines as a permanent part of an engineering structure is of course not entirely novel; but in general they have been used only for such structures as tall standpipes, steel chimneys, derrick poles and similar high and slender objects. Their application to hold erect a timber framework, 50 to 150 ft. high, and only 24 ft. wide at the base, is, so far as we recall, unprecedented. We see no reason, however, why their use should not be entirely successful if the strains put upon them under various conditions of loading, tightening, temperature and wind pressure are all correctly determined and provided for. It may be pointed out, however, that such a construction would be much more appropriate with a wooden structure with its large elasticity than it would be with a steel structure, such as a standpipe for example, which is too stiff to accommodate itself to the variation in tension of the guy lines.

A guy rope, like the cable of a suspension bridge, is necessarily a flexible member, and is subject to vibrations, which are especially great when the wind is high. A wooden structure has elasticity enough to accommodate itself to the changes of stress which these vibrations produce. To put the matter in another way, a structure like the Cranberry Mine breaker is held erect against lateral forces, first by the bracing of its frame-work, and, second, by the guy lines. It is necessary that these two systems shall act in harmony, just as in the case of two different systems of bracing in a bridge truss. One reason for the lack of success in the use of guy ropes for stand-pipes may be that the stand-pipe is so stiff that it becomes crippled by wind pressure before the guy line takes its proper proportion of the stress.

The construction of a trunk railway line in Cuba, with branches to the coast, is suggested by Secretary of War Alger on the ground that it would afford employment to thousands who would otherwise be dependent upon charity. Aside from this, however, it is doubtless true that the improvement of the means of internal communication is the first and all-important step in the development of the island. Such an expenditure of public money for charity alone would hardly meet with popular approval; but it is very probable that such a railway would eventually prove a profitable enterprise if it were properly constructed and operated. Cuba now has about 1,100 miles of railway track, connecting Havana with the town of Pinar del Rio, on the west, and Santa Clara, or the port of Caibarien, on the east; but the whole eastern half of the island is without railways, excepting only a north and south line in the Province of Puerto Principe and the mineral roads in the vicinity of Santiago de Cuba. The distance between the latter city and Santa Clara is about 300 miles, and it is to the construction of a main line from Santa Clara eastward and its branches that Secretary Alger doubtless refers.

Cuba is approximately 800 miles long, and from 30 to 160 miles wide, and is thus topographically well adapted for the location of a trunk line which with its branches would provide means of access to the greater part of the island. Its common roads, though abundant upon Spanish maps, can hardly be depended on as feeders to a railway system. As one writer puts it—the art of road-making in Cuba is not a lost art, for the very good reason that it never existed; and the loose character of the soil, combined with a tropical rainfall, convert existing roads into almost impassable quagmires in the wet season, and covers them with thick dust in dry weather. Except in the vicinity of a few large towns there are no roads worthy of the name in Cuba; and this condition has been partly met on large plantations by the construction of light private railways leading to seaports or to stations on railways now in service. As highway construction is expensive in the island, these private railways will doubtless be increased in number for some time to come, as feeders to the main lines from agricultural centers. As a result of the notoriously inadequate transportation facilities under Spanish rule the development of the natural wealth of the country has been very slow, and not more than one-fourth of the island's surface has ever been under cultivation. Although valuable timber is abundant, the export of such timber has never exceeded $220,000 per year, and good timber land at any distance from a railway lately sold for less than one dollar per acre. The characteristics of previous rule in Cuba seem to have been an almost total neglect of local development and an almost prohibitive tax upon such industries as did exist under these conditions. As to the measure of this Spanish taxation, Mr. Wm. J. Clark, in his recent book "Commercial Cuba," tells us that while, in 1894, the total value of the agricultural products of the island was about $85,000,000, the total tax gathered in that year by the "Mother Country" was nearly $23,000,000.

With this tax incubus removed and modern and civilized methods substituted for the obsolete Spanish rule, the future commercial possibilities of Cuba can hardly be estimated. But the better sanitation of large towns and the improvement of ways of internal communication are the all-important first steps, whether undertaken directly by the government, or by private individuals under government control. The latter seems to us the better method; and it would provide equally well for the employment of the destitute. Capital is abundant in the United States and seeks just such investments as Cuba can offer; provided, that the government will insure stable conditions and will hasten, by all practicable means, the restoration of the island to peaceful conditions.

An interesting legal controversy has arisen at St. Paul over the question whether a railway company is responsible for damages done by its trains to a structure crossing its tracks overhead, which is owned and maintained by the city and which was placed there after the railway tracks were built. The accident which gave rise to the controversy is described in our Correspondence department in this issue, and we think it is worth especial notice by engineers as an instructive lesson in the design of viaducts for crossing railway tracks. Derailments are always a possibility in the movement of cars and trains, especially in large yards where switches and frogs are numerous; and an engineer designing any structure to be placed above railway tracks should endeavor, if possible, to so place or so design its supports that they may be reasonably secure against knocking down by derailed cars. It may not always be possible to do this. At times it may be necessary to place slender pillars so close to tracks that a derailed car will be pretty sure to destroy them and bring down the structure which they support. In these days of cheap concrete construction, however, it is generally possible to provide a monolithic masonry support for the columns of sufficient height and weight to withstand the shock of any ordinary collision, and to do this at no large expense. Here, as everywhere, the matter of safety is really a matter of dollars and cents; and if an engineer can show that at a moderate outlay he can make a structure reasonably secure against the danger of knock-downs by derailed rolling stock, he will generally be instructed to do so.

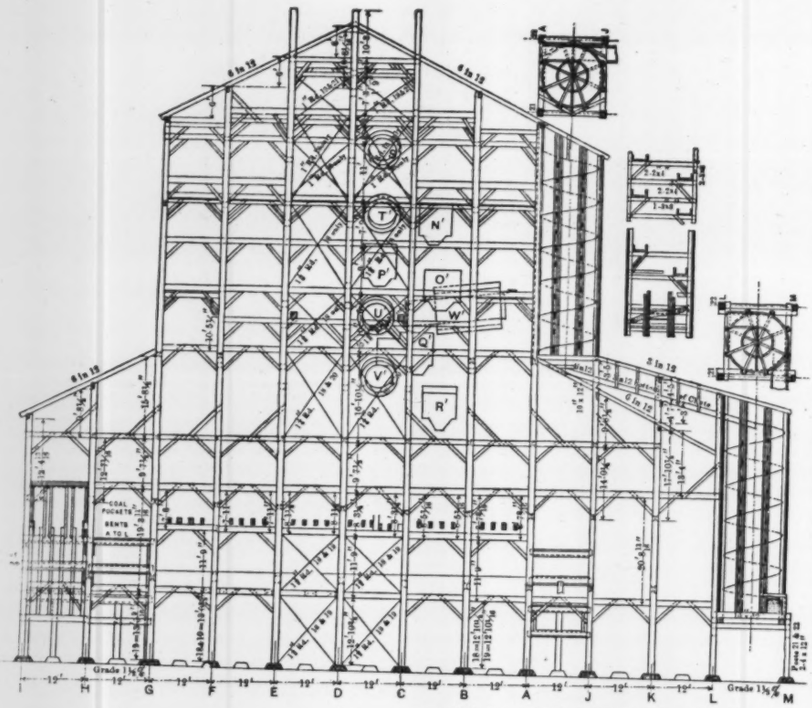
This matter is of interest not only in connection with the removal of highway grade crossings by the erection of viaducts, but as a matter to be considered in the design of railway stations. There are many old-time "through" railway stations where the brick wall which forms the end of the station is supported on a series of slender brick piers between the tracks. Such a structure may stand unharmed for a century; but whenever a derailed car does come along and strike one of these piers, the whole wall is bound to collapse.

The paper on "The Softening of Water by the Archbutt-Deeley Process," which we publish elsewhere in this issue, contains one of the best expositions we have seen of the chemical theory of removing scale forming ingredients from water. It also describes a new process of water-softening which seems to have a considerable advantage over the old Clark process, and which has met with much success in practice in several installations in England. We believe it would be worth while for large steam users in the country to investigate the merits of this process, with a view to substituting it for the "boiler compounds" they have been in the habit of using.

THE NEED OF IMPROVED METHODS FOR EXTINGUISHING FIRE IN HIGH BUILDINGS.

The need of improved methods and apparatus for fighting fires in tall buildings has received a very timely illustration in the partial burning of the 16-story Home Life Insurance Building, in New York city, on Dec. 4 (Eng. News, Dec. 8, 1898). This structure, taking it as a whole, was a good example of modern tall building construction in all the conditions with which firemen may expect to have to deal in fighting fires in such buildings. The amount of combustible contents was probably as small as it can be expected to be in buildings devoted to business purposes. The amount of inflammable wood-work could certainly have been less, but it was no more than is found in most similar buildings. The interior fireproofing acted almost perfectly in preventing the spread of flames from story to story. Indeed, the only broad feature of the fireproof construction which was essentially faulty was the lack of protection against the entrance of the flames from an exposure fire. Notwithstanding all this, it was found impossible, even with the excellent modern apparatus of the New York Fire Department, to combat the flames successfully above the eighth story, and when the fire had once become established above this level it had to be left to burn itself out.

Reasoning inferentially, this practically amounts to saying that the majority of modern tall buildings must be left to their destruction above the tenth floor when once a fire has obtained headway


EXPLANATION
N' 4-BROKEN COAL JIGS
O' 4-EGG " "
P' 4-STOVE " "
Q' 4-CHEST. " "
R' 2-PEA " "
S' 4-STEAMBOAT AND BROKEN SCREENS
T' 4-EGG AND STOVE SCREENS
U' 4-CHEST. AND PEA SCREENS
V' 4-BUCK. AND NO. 2 BUCK. SCREENS
W' 2-EGG, STOVE, CHEST. AND PEA SCREENS

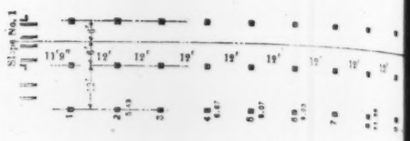


FIG. 3. CROSS-SECTION AT BENT NO. 18.

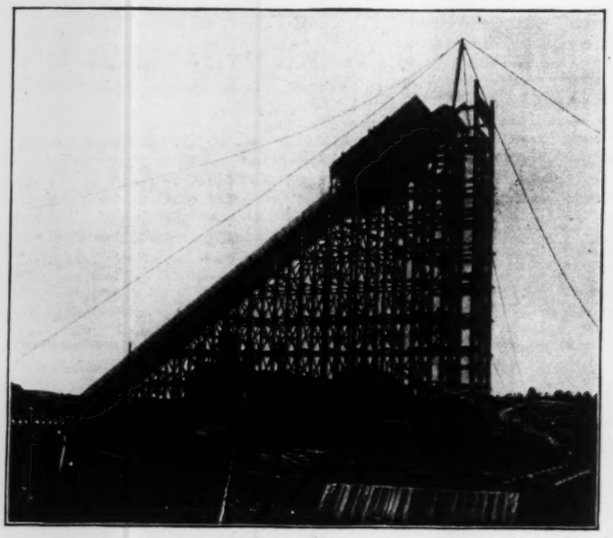
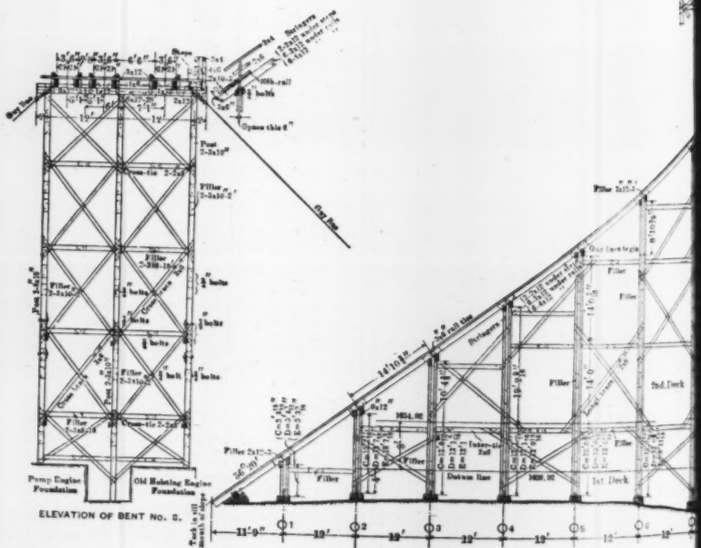
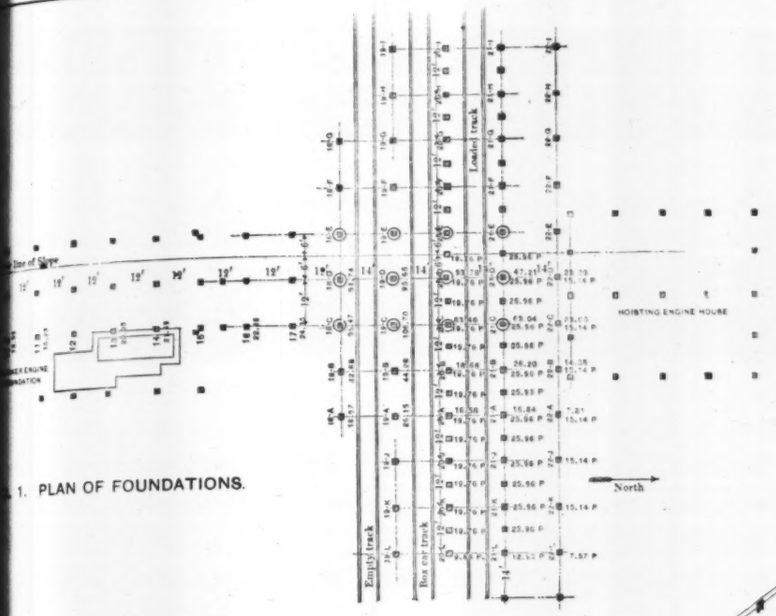


FIG. 4. BREAKER IN PROCESS OF ERECTION.

ANTHRACITE COAL BREAKER AT THE CRANBERRY MINE, HAZLETON, PA.

W. S. Ayres, M. Am. Inst., M. E.,
Chief Engineer.





1. PLAN OF FOUNDATIONS.

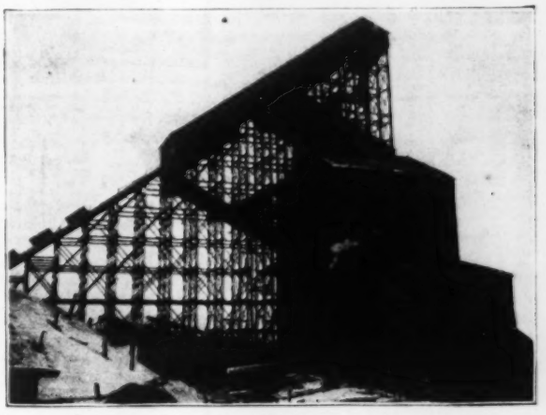
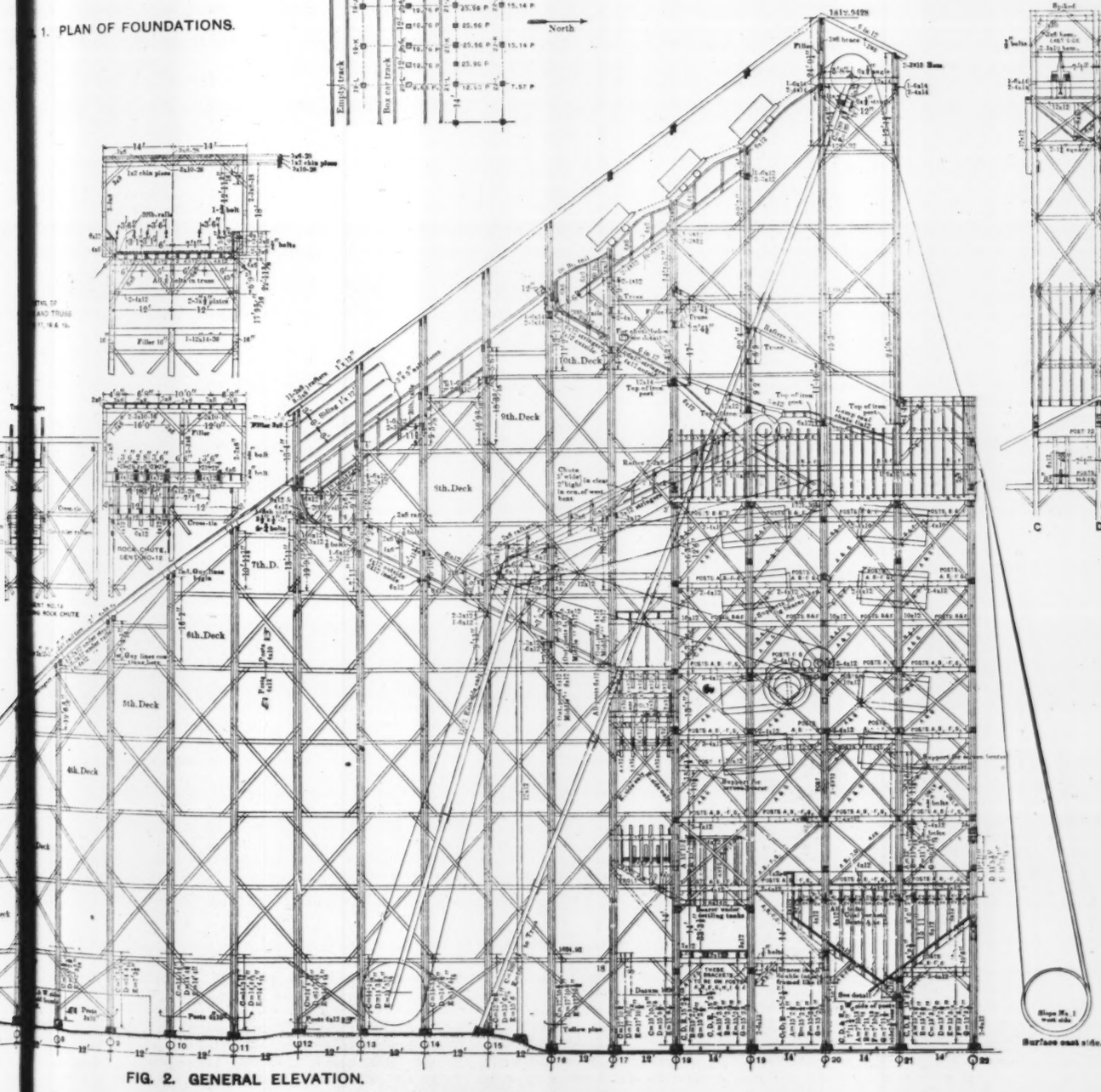


FIG. 5. VIEW OF COMPLETED BREAKER.



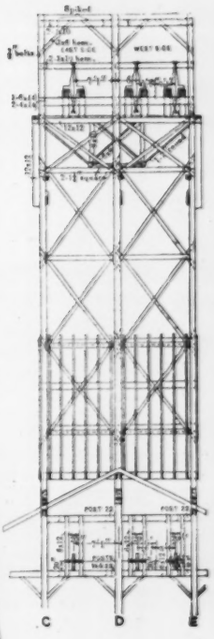


FIG. 2. GENERAL ELEVATION.

there. That there is good cause on this account to be dissatisfied with fireproof construction for such buildings, however, no one who studies the facts will believe. Indeed, in this building, and wherever fireproof buildings have been subjected to fire, there has been every reason for the owners to congratulate themselves that their buildings were well fireproofed. The thing which is clearly proven by the Home Insurance Building fire is that the tall building has introduced conditions in the fighting of fires which require improved devices to meet them. It is this phase of fire protection particularly which will be considered here.

The difficulty of fighting fire in a tall building is due to the fact that it is tall, and to nothing else. At over 125 ft. above the street modern fire apparatus is not and cannot be made efficient in fighting fire from the street level. For high buildings, therefore, it must be supplemented by devices for getting water and firemen above this level, as high in some cases as 300 ft. above the street. (There are five buildings in New York city, the "Syndicate," "St. Paul," "American Tract," "American Surety," and "Commercial Cable," which are 309 ft., 308 ft., 306 ft., 306 ft., and 304 ft. high, respectively.) Not only is it necessary to get water in ample quantities and with high pressures to the tops of these buildings, but there must also be means provided for getting firemen with their hose and other paraphernalia to the same points.

For transporting the firemen and their apparatus the stairways and elevators must serve as else. At over 125 ft. above the street modern and their goods under ordinary circumstances. They must operate, however, under far different conditions than they do ordinarily, and should be designed with that fact in mind. Consider first the common staircase as the means of access to the upper floors where a fire is raging. A 50-ft. section of ordinary 2½-in. cotton hose weighs from 56 to 60 lbs., and 250 ft. of 1¼-in. rope weighs 65 lbs. The carrying of either of these loads from story to story is a task which attains pretty serious proportions at any time, and which may, under certain conditions of inconveniently arranged stairways, or obstructions from smoke, become practically impossible, even with a fire of no very great proportions.

That this is not a merely theoretical criticism, a review of the role played by the stairways in some of the recent office building fires in New York city will indicate. In the comparatively insignificant blaze which occurred in the Vanderbilt Building on Feb. 11 of the present year (Eng. News, Feb. 17, 1898), the firemen were overcome by smoke and exhaustion several times in getting the hose from the street to the eleventh floor by the way of the staircase. Neither this stairway nor the adjacent elevator shaft were touched by the flames, and the only obstacles which the firemen had to overcome in surmounting the stairs were their crookedness and the presence of smoke. Again, in the case of the burning of the Temple Court and the Manhattan Savings Bank buildings, the slate treads of the stairways yielded to the heat, leaving the staircase with openings the full size of the tread, which made them impassable. Marble and bluestone, which are also continually used for stair treads, have proved equally insecure when attacked by fire and water. So little confidence, indeed, is felt in such stone treads that a well-known authority on fireproof construction has recently expressed the opinion that the staircase construction in 90 per cent. of our great office buildings would prove utterly unreliable for the use of firemen in the event of a fire of serious proportions.

These are serious considerations, especially as there is no good reason for a construction which is so insecure. The fault is due entirely to the prevalent construction, which is simply to let the stone tread into iron rabbit frames, with no support underneath them. To make the construction safe would require only that an iron plate, of openwork or gridiron pattern if desired, be placed underneath the stone tread and firmly fastened to the frame. Then if the stone broke or crumbled away there would still remain the iron plate, which would afford a safe support for the foot. Obviously also the staircase could be made entirely of metal, as is, indeed, sometimes done. By the exercise of a little taste the architectural aspect of the staircase would not suffer much by such a construction, and where the stairs are used so little as they are in high buildings, the greater insecurity of foothold afforded by cast-iron treads would not cut a very important figure. The metal construction would, if anything, be less expensive, and it certainly would be a great deal more reliable than the ordinary iron frame with unsupported stone treads.

But when it comes to providing access to the upper floors of a tall building, a stairway is about as crude a method for firemen and hose as it is for handling the freight and tenants under ordinary conditions. For this reason safety requires that all high buildings should have constantly present, day and night, some competent person understanding the elevator machinery, fire appliances, etc., who can aid the firemen in reaching the upper levels, and there should be sufficient steam in the boilers at all times to run one elevator. It was the lack of such precautions in the Vanderbilt Building which necessitated the hose being carried up the ten flights of stairs to the floor which was burning, with the difficulties and dangers to the firemen which have been previously enumerated. In the Home Insurance Building fire the one elevator which was running was used to great advantage until the progress of the fire in the upper stories rendered it inoperative. These two instances illustrate clearly the advantages of having elevator service available in the event of a fire, and also indicate the weakness of this service. These are so apparent, indeed, that it leads one to question seriously whether it might not be justifiable to provide in tall buildings one elevator completely inclosed in a fireproof shaft with solid doors which would be used only for freight service and in the case of fire. To ask that the regular passenger elevators should be inclosed is, perhaps, requiring too great a sacrifice of appearance and comfort on the part of the owners and occupants of tall buildings, but something might possibly be done even here to improve the present conditions if the matter were gone at in earnest.

The foregoing questions are, however, of secondary importance to the question of providing an ample water supply under efficient fire pressure on the upper stories of tall buildings. In all but a few such structures it is only fair to say that an attempt is made to do this. Generally it falls far short of its possible success, however, because of the failure to comprehend the full magnitude and character of the conditions to be met. The apparatus provided is too small for its purpose, and this is true not only of the roof tank supply and the interior pipe system and fire pumps, but also of the stand-pipes for the fire department. The full importance of these latter devices in fighting fire high above the ground seems to be very often overlooked. In many buildings they are not supplied at all, and in many others they are entirely inadequate for efficient fire service.

As indicating the importance of such stand-pipes, Fire Marshal D. J. Swenie, of Chicago, who has made a special study of fighting fire in high buildings, urges that they should not be less than 6 ins. in diameter; should have Siamese connections at the street for the fire department; should be provided with check valves, so that when the steamers are attached their force will be added to that of the building's pumps, and that there should be hydrants on each floor and on the roof. Finally, he urges that each floor should have hose connections with the stand-pipe, and sufficient hose to reach the most remote point of the floor above.

The providing of sufficient power to supply the stand-pipe with an ample amount of water under fire pressure, which is included in these requirements, is deserving of particular stress. It requires no small pumping capacity to keep up efficient nozzle pressure on a few of the upper floors alone of a 16 to 25-story building, and a special fire-pump for this service alone, which may not be called into use once in a decade, seems to owners a useless burden. The result is that the pump for the water supply is very often made to serve as a fire-pump as well, and is more than likely to be entirely inefficient to meet the demands when the crucial test of fire comes. A very obvious partial remedy, at least, which occurs to one in buildings where there is hydraulic elevator service, is to have the elevator pumps so arranged that they can be thrown onto the fire service in case of emergency. The provision described for bringing into service the aid of the fire engines is too obviously wise to need much urging. In the case of the building pumps becoming inoperative by the flooding of the basement or by some disabling accident, these fire engine connections afford the only means for getting water to the upper floors.

There is much reason also to urge that the control of the stand-pipe service should be placed entirely in the hands of the fire department in the event of fire, and be subject to the inspection and approval of this department at all times. This would enable the fire department to utilize the stand-pipes in extinguishing neighboring fires, as well as to protect the building in which it belongs. So evident are the benefits to be gained by such a system, in rapidity of getting the hose into service, in the directness and accuracy with which the water can be applied, and in the shelter afforded to the firemen, that the fire insurance interests would be warranted in insisting upon the general adoption of this requirement.

So far we have spoken only of increasing the efficiency of devices already in somewhat common use. There are many competent authorities on fire protection, however, who urge that a still longer step in advance is necessary, and that in all important cities the business section at least should have an auxiliary water supply system for fire protection only. In a recent report to his department, Fire Chief Bonner, of New York, argues in favor of such a system as follows:

> We must realize the fact that the capacity of land engines to force water to great heights has been reached. When greater power is required to force water to meet conflagration, and to great heights, it must be obtained from other sources than the steam fire engines now in use, and there is no system that could better be recommended than the one under consideration. There are high buildings in New York that are entirely beyond the ability of the machinery of the Fire Department to force water to the upper stories. It must also be considered that the tall buildings of the present day, as well as the mercantile buildings, are of greater height and cover larger areas than ever before, and that fires will entail great loss if not promptly checked. If the department is not able to control the fire and surround the structures with large quantities of water, there is a possibility that such fires will extend and become great conflagrations. This source of danger can be obviated by adding an auxiliary plant for the use of the department in the form of the underground pipe line, connected to a roof line system, as well as an aerial line, which should connect to all of the tall buildings. This should be fed from the underground system, and also from our city mains, with the aid of auxiliary pumps—electric or steam—located at different points in the city. By the use of the auxiliary pump water could then be forced to the topmost story of any building, no matter how high, as well as to the circuit on the roof line, and would render positive protection against any extensive fire in that section of the city.

Experience with auxiliary pipe systems of this character is not lacking, for the cities of Milwaukee, Detroit, Cleveland, Buffalo and Boston have already adopted them on somewhat limited scales with entire success. It is reasonable to believe, indeed, that where a plentiful supply of fresh water is available, as is the case in the Great Lake cities, such a system of pipes, into which water can be forced by powerful fire boats or from special high-power pumping stations, affords an almost ideal water supply for fighting fires. Where salt water has to be used, as would be the case in New York and other seacoast cities, the matter assumes greater difficulty. Here the danger of destruction to the pipes by corrosion, and the rusting tight of connections, valves and fittings by the salt water may constitute a serious objection, and before the adoption of an auxiliary pipe system at a great expense, this objection will need to be thoroughly investigated.

It has been possible in the foregoing to touch briefly upon only a few of the more salient features of the problem of fighting fires in tall buildings. Enough has been said, however, to show that it is a problem which is worthy of careful study by engineers, architects and underwriters. It is also apparent that the erection of a steel framework and covering it with clay tile, concrete, etc., does not create complete protection from damage by fire to the building and its contents, as the non-technical public is too apt to assume.

LETTERS TO THE EDITOR.

Technical Education of Railway Employees.

Sir: I desire to say that I have been requested to prepare a report for the next meeting of the International Railway Congress, to meet in Paris in 1900, on technical education of railway servants, the official wording being as follows:

Question XXXLV.—Technical Education of Railway Servants; Appointment and Promotion. (A) Attempts made by railway administrations to promote the technical education of their staff. Special schools for the technical staff. Primary schools for the children of railway employees and workmen. (B) Methods of testing the knowledge of railway servants. Appointment and promotion.

I desire, therefore, to ask any one conversant with the subject to transmit to me as soon as possible full information as to any course of instruction that they may be familiar with, and I shall take great pleasure in acknowledging receipt of the same. As some extended correspondence may be necessary, it is desirable that I have the first information in the immediate future. A reporter on this question has been appointed from each of the European countries, the one from Switzerland being the General Manager of the St. Gothard, and the one from England being Mr. George Gibbs, General Manager of the Northeastern Ry. I presume it would be the desire of all Americans interested in this subject that our report should be as complete as possible.

Very truly yours,
Geo. B. Leighton.

Los Angeles Terminal Ry., 712 Rialto Bldg., St. Louis, Mo., Dec. 13, 1898.

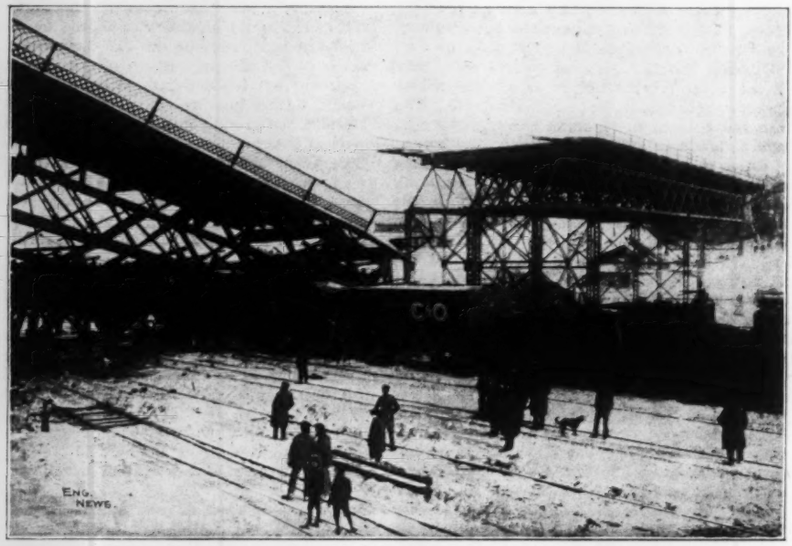
Relating to Mr. Garrels' Pamphlet on "Experiences with an Internal Combustion Motor."

Sir: My good opinion of the Engineering News, to which I have subscribed for a number of years, has caused me to take the trouble to answer a criticism, to which my attention has been called, concerning myself, that appeared in your Supplement of Dec. 8, p. 182. As I believe you do not intend to treat me unfairly, your sense of justice will no doubt cause you to give my reply as prominent a place in your paper as you gave the criticism. My critic thinks we should have taken the matter into court. Permit me to remind him that before doing this it is desirable to have as much relevant information as one can get, and to point out to him that this was my purpose in gathering information concerning this engine, a proceeding which impressed him as being extraordinary. Permit me to say further that it was upon information carefully gathered that we based our opinion that it would be a useless expenditure of time and money to take the matter into court. The writer is under the impression that these facts are brought out in the pamphlet. The uselessness of sueing is surely clearly shown. In the writer's humble opinion the pamphlet is interesting not merely with respect to internal combustion motors, but because it describes the peculiar business methods of certain firms, and this opinion has been confirmed, not only by the large number of letters received inquiring for copies, but by the statements of some men of recognized ability, some of them engineers financially interested in internal combustion motors. My critic's doubt as to the libelous nature of the pamphlet does not agree with the opinion of my attorney. Does the former expect to raise my opinion of technical papers by such a criticism?

Respectfully,
W. L. Garrels.

Franklin Bank Building, St. Louis, Mo., Dec. 14, 1898.

(If any of our readers are further interested in the subject matter of Mr. Garrels' pamphlet we have no doubt he will send copies on application. —Ed.)



WRECK OF THE SIXTH ST. VIADUCT OVER YARDS OF ST. PAUL & DULUTH R. R., ST. PAUL, MINN., DEC. 7, 1898.

(From Photograph taken half-an-hour after the Accident, showing Fallen 100-ft. Span and the Train which Caused the Accident.)

Wreck of a Viaduct Over Railway Tracks at St. Paul, Minn.

Sir: I send you herewith photographs of an accident which occurred in this city on Dec. 7. A freight train coming into the yard of the St. Paul & Duluth R. R., at 10:30 a. m., passed a stub switch. The switch was set for the right-hand track, and the engine, one freight car and the forward trucks of the second car passed safely. The switch then turned back, owing to a break in the crank of the switch rod at the stand, and the rear truck of the second car and the balance of the train, some 17 loaded cars, took the left-hand track. The two tracks continue parallel for some distance, and 700 ft. from the switch there stood between the tracks a steel bent supporting a viaduct which carried a street over the railway yards. The viaduct was 60 ft. wide, and the spans whose ends rested upon this bent, were, respectively, 80 ft. and 100 ft. long. The car with its forward trucks on one track and rear trucks on the parellel track struck this bent and knocked it down, and the two spans fell as shown. Luckily but one man was on the wrecked portion of the bridge, and he is in a fair way to recover. The damage to the train was confined to the first and second cars of the train. The principal damage therefore is to the bridge. To rebuild the two wrecked spans would cost about $12,000.

The railway company at this date has claimed that it is not to be held responsible for the accident. The city condemned the street across its right of way and built the bridge at its own risk. The city claim that the railway company so operated its trains and arranged the tracks that it caused the wreck, and therefore it is bound to replace the bridge. At present, the matter stand in this shape, and it is probable that neither city nor railway company will pay for renewing the structure until the courts have passed upon the matter.

Yours truly,
Geo. L. Wilson, Asst. City Engr.

St. Paul, Minn., Dec. 12, 1898.

Estimating Cost of Rock Excavation.

Sir: The estimated cost per cubic yard of excavating rock in a cut, tunnel or shaft is a problem continually presenting itself to engineers. In my own experience this cost varies from less than $1 to $18 per cu. yd. The usual method of getting at the cost is to divide the work under the heads of labor, explosives and tools, and to subdivide these items as may be considered desirable. But while this method will do very well for work performed, it does not apply to work yet to be done; and in the latter case the correctness of the result depends largely upon the experience of intuition of the engineer. Under these conditions the following method of estimating cost is suggested:

To drill and blast a boulder containing one cubic yard will cost not far from 60 cts., and I have assumed this cost as one unit in the calculation. But as the rock to be handled is not always in the form of boulders, but occurs as ledge, or cutting to grades and lines, more or less exactly, the cost is increased by another factor. It occurred to me that working to line in a rock cut was somewhat similar to dressing a stone in a quarry; and as the cost of cutting rough beds on stone was about 20 cts. per square foot, I adopted this as the other factor, and thus evolved the following rule:

To the volume of rock to be removed, calculated as common open quarrying at, say, 60 cts. per cu. yd., add the number of square feet of surface in the bottom and sides of the proposed cut, figured at 20 cts. per sq. ft. This sum divided by the number of cubic yards in the mass will give the probable cost per cubic yard. For tunnels multiply the resulting yard price by two; and for shafts, by three.

A few examples will show how this rule works: Ex. 1.—A rock cut 108 ft. wide by 25 ft. deep measures 100 cu. yds. per lin. ft. of cut; and it has 158 sq. ft. of working surface for the same length unit. These two factors multiplied by 60 cts. and 20 cts., respectively, give $91.60, or 91.6 cts. per cu. yd. Ex. 2.—A rock cut 108 ft. wide and 1 ft. deep measures 4 cu. yds. per lin. ft. of cut, and has 110 sq. ft. of working surface. Calculating again at 60 and 20 cts., we have $22.40, or $6.06 per cu.yd. From the second example we will see that if a mistake is made in leaving the grade 6 ins. too high, it will cost $11.50 per cu. yd. to cut it down this 6 ins., as a separate operation.

As tested by experience the factor prices of 60 and 20 cts. come very near the actual cost in many cases. And contrary to the usual assumption, the hardness of the rock does not vary the result very materially; and it would seem that the dimensions of the cut have much more to do with the cost of excavation than the quality of the rock. I simply suggest this rough rule that it may be further tested by engineers.

Very truly,
John F. Ward.

New York, Dec. 19, 1898.

More Light on the Morgan Bill for the Purchase of the Maritime Canal Company's Concession.

Sir: I have read with great interest your admirable editorial on the Morgan bill, and ask space to make a few comments on the bill and on the Maritime Canal Company. The Morgan bill provides for a board of eleven directors, one of whom shall be appointed by Costa Rica, one by Nicaragua and nine by the President of the United States.

Article X. of the Concession from Nicaragua provides as follows:

Its board of directors shall be composed of persons, one-half at least of whom shall be chosen from the promoters who may yet preserve their quality as such.

Article XI. reads:

The Government of Nicaragua shall have the perpetual right of naming one director, who shall be an integral part of the board of directors of the company.

Article X. of the Concession from Costa Rica confirms the same right to Costa Rica. Under the terms of these concessions at least six of the eleven members of the board must be selected by the President of the United States from among the original promoters of the scheme, thus putting the organization of the board into the hands of the old Maritime Canal Co. The bill seems to have been drawn all the way through with this in view. It provides that "the canal *may* be constructed under the supervision of the Engineer Department of the United States Army if the President of the United States shall so direct" (italics mine). "Otherwise the board of directors shall appoint all the engineers in the service of the company."

Why not make it mandatory that the work shall be done under the direction of the Corps of Engineers of the U. S. Army? Are the people of this country willing to turn over to the Maritime Canal Co. $100,000,000 to $150,000,000 to be expended as they see fit? Especially when their annual reports show that they have issued stock and bonds to the amount of $23,471,500, and only claim to have expended from $4,000,000 to $5,000,000.

Under the terms of the bill, the company may default in the interest every year until the maturity of the bonds in 1926, and no steps can be taken to enforce the collection. The lien of the United States on the work cannot be enforced until the maturity of the bonds.

The act also provides that if default is made in the payment of the principal, the United States may take possession, and "thereupon the full and complete title to all such property, rights, privileges, easements, or franchises shall vest absolutely in the United States." This is clearly contrary to Article VIII. of the Concession, which prohibits the transfer to any government. This is not an evasion, but a clear violation of the terms of the Concession.

If the new Maritime Canal Company is to be made up from persons connected with the old one, it behooves the government and the people to examine into their business methods in the past.

We find here a company attempting to carry out one of the largest engineering enterprises of modern times, without ever having had an engineer in their employ. Mr. A. G. Menocal was the chief engineer of the Construction Company; his reports are addressed to them, as is also the report of the Bogart board.

In his statement before the Congressional Committee Mr. Menocal states that he never saw the contract which was said to exist between the Maritime Company and the Construction Company, and yet he was carrying out the work under that contract. The Maritime Company are said to have paid the Construction Company from time to time for work done. How did the Maritime Company verify these accounts? They had no representative or engineer at Greytown. Or were they simply a bureau to charge up whatever the Construction Company presented, and then ask the Government of the United States to take these accounts off their hands for a lump sum ranging from $11,000,000 to $5,000,000, the amount depending on the length of time the Concession still has to run?

Before making any such purchase it behooves the government to untie the bag and view the pig.

The Government of Nicaragua have repeatedly stated that they would prefer to negotiate directly with the Government of the United States, and have the canal built directly as a government work. If this were done and the work were put under the control of the Corps of Engineers of the U. S. Army, there is no doubt but the canal would be well built and there would be no scandal connected with it.

Subscriber.

Dec. 19, 1898.

Some Observations on a United States Transport.

Sir: Apropos of the recent criticism of the War Department, and with special reference to transport ships, the writer was, up to a few weeks ago, in a position particularly favorable for close observation of many of these vessels; a statement of some of the facts of special moment might therefore be of interest to the engineering public. Concerning the chartered vessels much might be said, but it is not intended to consider them here, since their position was peculiar and the "Charter Parties" weak.

It is to six vessels purchased from a Transatlantic steamship company that attention is invited, taking one of these ships in particular as a fair representative of all. It is thought perfectly fair to consider that all of these ships were in very nearly the same condition at the time of their acquisition by the War Department, as all were about the same age and had done about the same amount of work in the Transatlantic trade. All apparently had received about the same amount of attention with respect to maintenance. At the beginning of the peace negotiations between the United States and Spain, one of these six ships was taken out of service and sent to a well-known shipyard for repairs and permanent refitting as a transport, and it was while acting as resident inspector of this refitting that the writer became acquainted with the exact condition of this ship by close personal examination.

It is a modern, twin-screw, steel steamship, 445 ft. long by 49 ft. beam and 39 ft. deep; draft on load water line 26½ ft.; six athwartship bulkheads and double bottom throughout. She has two single and two double-end Scotch boilers and two triple expansion engines of the fore-and-aft type—that is, three cylinders, each working on its own crank. The piston rods of the intermediate and low pressure engines extend up through the cylinder head, and these tail-rods were the most noticeable objects to one entering the engine room. They were so badly cut and fluted that it is hard to see how the ship had run at all, so difficult it must have been to keep any packing in the stuffing boxes. On close examination, nearly all the piston rods and valve stems were found in a varying degree in the same condition, and all had to be turned down to permit the stuffing boxes being packed with metallic packing. This turning down was considerable; one rod, for instance, was reduced in diameter from 4 to 3⅛ ins.

The valves of the high pressure engines are of the piston type, the others being slide valves. These piston valves were found on removal to be rusted on their faces, showing that the steam had blown freely around them for a long time, and the slide valves were very badly cut in grooves and furrows over ⅛-in. in depth. Another noticeable feature which was an index to the apparent character of the previous maintenance of the ship was the condition of the bearings of the valve gear rock shafts on each engine. These bearings contained an upper and a lower brass, which, in the course of time, had worn away until the bearing was "brass bound"; instead of relining these brasses or properly taking up further wear, a wooden stick had been driven in between the shaft and the upper brass of each bearing. To all appearances these bearings had been in this condition for many months.

Among the auxiliaries the condition of things was very bad. The boiler feed pumps were unfit for any use and the water piston of the principal pump was so much smaller than its cylinder that a large pocket-knife blade could be run all around between it and the sides of the cylinder. In the boiler room probably a little more attention had been given to proper maintenance, as the boilers had been kept fairly clean inside; but some of the boiler mountings, such as drain valves, and some of the stop valves, were so badly corroded that they could be neither opened nor closed without destroying them. Connecting the bilges of the various compartments are gates or sluices in the bulkheads at each side of the ship worked by rods running up to the spar deck. Connected to each of these bilges is a hand pump. Neither the sluices nor the pumps were in working condition, and, to all appearances, no attempt had ever been made to keep them in order.

The tanks in the double bottom, with the exception of the engine tank-head, evidently had not been cleaned for a long time, and probably never. The manhole covers had certainly not been removed within a year. Beneath the ceiling the lower holds were foul with decaying grain, the odor of which filled the lower decks and hold of the ship. This is a ship that for five years previous to last July had carried first-class passengers between New York and London, and then made a trip to Porto Rico, thence to Santiago de Cuba, thence to New York and thence for repairs. While on the voyage to the West Indies the former crew remained with the vessel, and it is reasonable to consider that the vessel did not get into such deplorable condition on the last short voyage.

It is not the intention of the writer to find fault with the War Department for purchasing and operating ships in this condition, because these were practically the only ones available that were at all suitable for the purpose for which they were required, and the urgent necessity therefore was a sufficient excuse. But is there any justification for the management of a Transatlantic steamship company, carrying passengers as well as valuable cargoes, cutting its operating expenses to a point where the engineering department of the company is unable to make a better showing than in the case of the ships referred to above? Is it not remarkable that there are not more "Mohegans" lost at sea?

Yours truly,

Eugene Betts.

New York, Dec. 14, 1898.

A Question in Engineering Ethics.

Sir: I enclose a slip cut from a daily paper published in a neighboring town in this state (Indiana), giving a statement of the business transacted in regular Council meeting. The item speaks for itself, but it may be well enough to call attention to the fact that the company in question publishes a journal ostensibly in the interest of engineers and depends for its support upon the advertisements of this same body of men. Of late several items have been published in the journal upon the ethics of engineering, and some of the experts referred to have been very much exercised over the low standard of ethics in the engineering profession. No further comment is necessary.

Yours,

Oct. 28, 1898. E. A. P.

The clipping enclosed is as follows:

The Municipal Engineering Co., of Indianapolis, made a proposition to the council through their special representative, Mr. Charles G. Lohman. This proposal embodied the retaining of the company as advisers in all technical questions which will arise in regard to sewerage, street paving, and public improvements of all kinds. The company employs experts in all these lines whose business it is to answer all questions asked by officials of the cities which have retained their services. This saves these cities all the expenses they would otherwise entail by the hiring of experts at such a time. After some discussion the motion was made by Rinehart that the services of this company be retained at the $100 asked by them. The motion was seconded by Kibele, and the roll was called, which resulted in a tie vote. The vote was as follows: Yes, Rinehart, Kibele and Little; nay, Venis, Kreep and Poffenberger.

(In accordance with our usual rule, we submitted a proof of the above communication to the parties criticised, with an invitation to present their side of the case. We append their reply as follows:)

Sir: Both the communication and newspaper clipping, as stated, are erroneous and misleading. Municipal Engineering Co. has not offered or undertaken to furnish engineering service to any municipality. The information service supplied to municipal officials by Municipal Engineering Co. is purely educational, and prepares them for better understanding and appreciation of their need of engineering service, where it may be required. In all cases where there is need of such service, we inform the inquirer that an engineer should be employed, and we advise engineers through our special bulletins to them that there may be opportunity for such employment, but Municipal Engineering Co. does not offer to render this engineering service. Our information service in no way conflicts with the interests of engineers or with professional ethics; it is, on the contrary, helpful in the largest possible measure to engineers, as many of them have realized, and we strictly and faithfully live up to the standard advocated in the articles on engineering ethics in "Municipal Engineering Magazine," referred to by the writer; possibly the writer of the above misleading communication has suffered some from these criticisms. Engineers are among the most zealous advocates of the service referred to, as it in no way unfavorably affects them, but, on the other hand, they profit by it, as information on technical matters, such as we furnish to officials, brings better appreciation of engineering skill.

Municipal Engineering Co.,
William Fortune, Pres.

Indianapolis, Ind., Oct. 31, 1898.

(As we have no desire to give publicity to any "erroneous and misleading" statements, we delayed publication of the above letters and undertook an independent inquiry as to the fact in controversy, viz.: Whether the Municipal Engineering Co. offered to render engineering service to the city in question or not. We addressed inquiries on this point to some of the members of the council of the city referred to in the above newspaper clipping, and have received the following answer:)

Sir: Your inquiry of Dec. 3 received, in regard to the proposition made by Mr. Chas. G. Lohman, representing the Municipal Engineering Co., of Indianapolis, Ind. The company did not offer to render engineering service. Simply that they were at our service as consulting them on any technical question, or would be our advisers for one year if the proposition was accepted. The Municipal Engineering Co. claims to have employed experts on all topics, which would render valuable service in regard to information furnished by them.

Yours very truly,

Cuno Kibele.

Bluffton, Ind., Dec. 5, 1898.

(The question which will doubtless puzzle our readers is: What sort of information or advice did the company propose to render to cities on technical questions that would not be rendered by a competent consulting engineer? We believe we can explain the seeming contradiction which appears in both Mr. Fortune's and Mr. Kibele's letters. A curious idea of engineering exists in certain rural sections. This idea may be expressed by the following definitions: 1. Surveying is making measurements in the field with the aid of a compass. 2. Engineering is making measurements in the field with a transit or a level. Thus the city engineer in many small cities is required merely to make measurements for streets, grades, sewers, drains, etc. That he should be also an adviser concerning the design and construction of pavements, sewers, water supply systems and similar city improvements or should be placed in charge of such work, never appears to be thought of. We may also add that in these same localities the value set on an engineer's services is in close relation to the above idea of his sphere of action.

But, it may be asked, if the term engineering is limited to the purely mechanical work with measuring instruments, what name is given to the real work of the engineer in the design and supervision of construction work—what we may call the "knowing how?" To the best of our knowledge the "knowing how" is not thought to be worth paying for at all in such places. Any alderman is supposed to know how to look after street paving, highway construction, sewers and drains. In case a contract is let for work, the contractor is supposed to furnish the "know how," for nothing.

To return now to our correspondent's original criticism, it is fair to say that in the present unformed state of ethical standards in the engineering profession, we know of no reason why the publishers of a technical journal may not, if they choose, conduct a consulting engineering business; nor why they or any other consulting engineer may not solicit engagements in which the payment will be by the year instead of by the job. The extent to which it would compete with its own patrons is a matter for it to decide for itself. We are somewhat inclined to think that the towns which it may induce to engage its services will be towns which would otherwise be little likely to engage the services of any consulting engineer. In this way it may, as it claims, be doing missionary work for the profession.—Ed.)

Spacing Stiffeners in Plate Girders.

Sir: I have noted with much interest the discussion regarding the spacing of stiffeners in plate girders in several of the last issues of the Engineering News. In Prof. Turneaure's observations on a plate girder with an extenso-

meter, described in the issue of Sept. 22, it might be of some value to know where the extensometer was applied, i. e., whether on the outstanding leg of stiffener angle or on the leg against the web plate, and also whether any reading was made on the same stiffener from the opposite side of girder. Unless readings by the extensometer were made on both sides of the girder, a possible solution for the case of those stiffeners which apparently showed tension instead of compression, might lie in the fact that while the outer edge of the stiffener might be in tension the opposite side of stiffener, and the stiffener as a whole was acting in compression, analogous to a column eccentrically loaded. This is an occurrence which was observed in the course of some investigations made on a girder a year ago by Mr. C. A. P. Turner, described in "The Transactions of the Engineers' Society of Western Pennsylvania, of September, 1897," in which the writer assisted.

One point noted in these observations by means of the galvanometer, was that readings taken on the stiffeners showed them to be in compression, and readings on the web in the path of the diagonal of a Pratt system showed tension, while readings taken outside of this broad belt of the diagonal upon the neutral axis gave no positive or determinate readings. These results seem antagonistic to Prof. Turneaure's statement that, "there is as much reason to suppose that the web stresses follow down the web and up the stiffeners, as in a Howe Truss, as to suppose that they follow the lines of a Pratt Truss." In the galvanometer readings referred to, the galvanometer responded very freely to the application and removal of load, thus seeming to preclude the possibility of incipient failure. Your very truly,

F. G. Skinner.

Minneapolis, Minn., Sept. 29, 1898.

Sir: For trespassing further upon the space in your columns in continuance of the discussion of the internal stress in plate girders, the writer will plead the excuse that the letter of Prof. Turneaure, in your issue of Sept. 22, would, without comment, make the experimental results obtained by the writer appear in a false light, and that, having made several hundred measurements on all parts of the experimental girder illustrated in your issue of Sept. 8, and having checked the general results by three or four different experimental methods, perhaps a more concise statement of the results obtained may lead to a more rational and general analysis of the internal web stress than that presented by the average text-book.

Let us first refer to the analysis of the internal stresses in beams in Rankine's "Applied Mechanics," and we find that the case examined by him is that of a beam of constant section along its length. For such a beam he proves clearly that the principal stresses at the neutral axis are tensile and compressive, acting at 45° with this axis and at 90° with each other. The special case of a beam of a given type of cross section increasing or decreasing regularly in sectional area along its length is amenable to similar mathematical analysis, and the general distribution of the internal stress would vary but slightly from the first case considered, as stated in applied mechanics. The general case of a beam varying irregularly along its length, both as regards area and type of section, is quite a different problem, involving too many conditions to be handled in a general way. Even the special cases, when the variations are at regular intervals with a constant section between are by no means simple and easily analyzed.

Since built sections, when well riveted, act under stress approximately as solid sections, we should consider the built

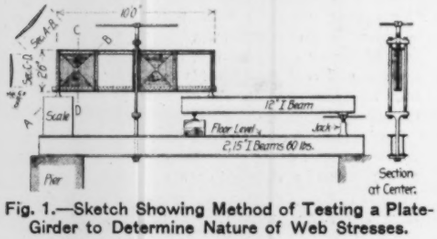


Fig. 1.—Sketch Showing Method of Testing a Plate-Girder to Determine Nature of Web Stresses.

girder with stiffeners as coming under the latter class of beams, and the writer would subdivide such girders into general classes as follows:

(1) Those girders in which the stiffeners are spaced economically; that is, sufficiently close to prevent buckling of the web and cause it to be capable of fully developing the strength of the flange.

(2) Those girders in which the stiffeners are placed needlessly close together.

Class 1 includes those girders in which the designer has followed Cooper's excellent specifications, in which he requires stiffeners to be placed about the depth of the girder apart when the shearing stress on the web exceeds that allowed by the formula given. The experimental girder belongs to this class, Fig. 1. The web of this girder was 30 × ⅛-ins. × 10 ft. Top flange, two angles, 3 × 3 × 5-16-ins. Bottom flange, two angles, 3 × 2½ × ¼-ins. Stiffeners at center, four angles, 2½ × 2 × 3-16 ins.; all others, two angles, 2 × 2 × 3-16 ins.; fillers ¼-in., rivets ⅝-in. diameter. Area top flange 3.56 sq. ins.; of bottom flange 2.62 sq. ins. or 2.37 sq. ins. net, practically two-thirds the area of the top flange. Under the usual theory, figuring the experimental girder as though the stiffeners did not affect the internal web stresses, we would have the strain per square inch in the bottom flange about 30% greater than in the top flange, while as a matter of fact it was 6% less. The average deflection noted in a series of readings with the same load repeatedly applied being 25.5 cm. top flange (average both sides); and 24.1 cm. bottom flange (average both sides). This discrepancy can be accounted for only by truss action, as the error of measurement with as expert an instrument man as Mr. Frank McIntyre, who took these readings, would be extremely small.

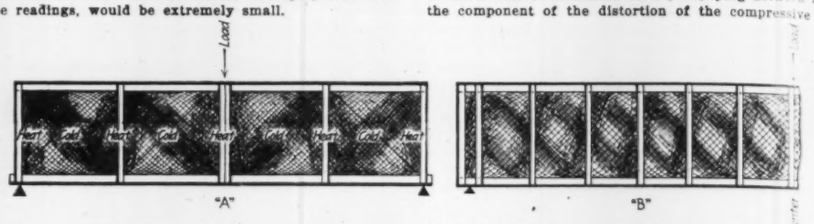


FIG. 2.—SKETCHES SHOWING DISTRIBUTION OF STRESSES IN PLATE-GIRDER WEB AS DETERMINED BY TESTS.

The next proof of truss action, as stated in your issue of Sept. 3, was the springing of the buckled web, which increased gradually with the increase of the load and going back with and apparently proportional to the removal of the load.

The maximum load in this case was insufficient to produce any set whatever, the maximum shear per square inch of sectional area of the web being under 7,500 lbs. and maximum flange stress under 18,000 lbs. per square inch. In this connection also it should be noted that in the panels with the flat web there was no tendency apparent in the plate to wrinkle nor any sign of lateral deflection.

With the thermal junction on the neutral axis of the girder attached to the web plate, either near a stiffener or in the center of a panel, the galvanometer would indicate almost the initial application of the load, the deflection obtained with the junction attached near the stiffener being the reverse in direction of that obtained when the junction was attached in the center of the panel, the wiring remaining the same, thus differing from the I-beam lever on the neutral axis of which we were able to obtain no positive deflection when the load was applied as should be the case under the usual theory. To attempt to account for this result on the ground of incipient failure, when we know the load to have been increased from a few hundred pounds to twenty tons concentrated load on the center of the girder, would indeed be rather grotesque theory.

Finally, the condition of stress, as nearly as the writer is able to determine from several hundred recorded observations, is something like sketch "A," Fig. 2. Here we note:

(1) That the lines of maximum compressive stress in the web are concentrated as it were in the dark area near the stiffeners and that they have changed in direction from 45° being deflected towards that portion of the plate best able to resist compression by virtue of the lateral support of the stiffener angles.

(2) That the path over which the maximum stresses act is but slightly longer than it would be were the tensile and compressive stresses acting at 45° with each other.

It is evident that the intensity of the stresses in the dark area in excess of those in the other portion of the plate are a direct function of the size of the panel, and an inverse function of the thickness of the plate.

Were the stiffeners applied vertically and so close together that the web is practically stiffened all over, it would undoubtedly be in a similar condition of internal stress to the plate of a flitched beam, which the common theory covers exactly. For cases between this extreme condition of excessive stiffening and that of stiffeners spaced economically, as investigated, we should naturally expect intermediate conditions of internal stress. A solution will be offered for one only of these as giving a fair insight to the treatment proposed for other cases.

Referring now to observations (1) and (2) concerning the distribution of stress shown in sketch "A," we may summarize the gist of these deductions in the words of Mr. Buel, that the load seeks the shortest course consistent with the strongest members. Now, under tension, it is true that the strength of a member varies as its sectional area, but under compression, sectional area alone is not the sole factor in determining the degree of strength and rigidity. For example, a 12 × ½-in. plate 10 ft. long would be almost worthless as a strut, while the same sectional area in the form of two 7-in. channels would make a strong and rigid compression member; likewise the stiffener by its form more than by its mere sectional area renders the plate under and near it stronger and more rigid under compression than that portion more removed from it.

Referring now to sketch B, Fig. 2, as in sketch A, we would expect the belts or areas of maximum compression near the stiffener and slightly inclined to it while the belts of maximum tension that act in connection with them in order to fulfill the conditions of following that path which would permit the least vertical deflection of the structure would naturally run to the alternate panel point, this being the shortest path consistent with the condition named that will allow the maximum compressive stresses to follow those portions of the plate which by the lateral support of the stiffeners is best able to resist them.

The point of most interest in this case, with a distribution of stress as outlined, would be that the stiffener would be strained much less than in the first case, sketch A, since the stiffener does not follow the center line of either belt of maximum stress, but lying between them the component of the distortion of the compressive belt along the length of the stiffener being offset in a measure by that of the tensile belt of the maximum stress crossing it at the center.

In sketches A and B, Fig. 2, the writer drew the lines of stress, as they approach the flange, convex towards it in order better to represent graphically his idea of the manner the components of the principal web stresses are transferred to the flange and the condition of strain on the rivets, instead of showing them concave towards the flange, the true position of the lines of principal stress in this portion of the web.

If, with a constant load, we should plot the readings obtained on the web along the neutral axis of the experimental girder, as ordinates with the distances from one end of the girder as abscissas, we would have a sinusoidal curve and the points where this curve passes through the value of $y = o$ would represent the only points where no deflection could be obtained by application of the thermopile when the load was applied. These points lie between the consecutive belts of maximum tension and compression shown in sketch A.

When the thermopile was applied to the plate between the neutral axis and the compression flange heating effect was noted, and the magnitude of this did not appear to increase regularly towards the center of the girder along a line parallel to the neutral axis as it should do were the web stresses uniformly distributed instead of being concentrated in belts, as shown in the sketch. Similarly, cooling effect was noted near the tension flange, indicating the extent to which the web was assisting the flanges in resisting bending.

The action of the stiffener in affecting the distribution of stress in the web plate may be regarded as twofold; first, in rendering the plate in its vicinity better able to resist compressive stress through the lateral support it affords, thus causing an uneven distribution of stress in the web, as shown in the sketch; and, second, under favorable conditions it may relieve the web of a considerable portion of the compressive web stress.

For the former action few rivets are required, but to act efficiently in the latter capacity, where the stiffeners are economically spaced, they should be well riveted as was the case in the experimental girder.

Merely investigating the condition of stress on one side of a few stiffeners in such a girder as selected by Mr. Turneaure would appear on this ground as an insufficient basis upon which to attempt to verify an assumed general analysis of the condition of internal stress of the stiffened plate girder.

As the experiment conducted by the writer is perhaps the first on record in which careful measurements were made of the internal web stresses of a stiffened plate girder, it is natural that some should be inclined to question both the accuracy of the work and the conclusions based thereon. To these, if sufficiently interested, the writer would suggest that as the method used by him is simple and practical, they may readily duplicate the work.

In conclusion, the writer would say that while personally looking after all details of the experiment conducted by him, the work was shared by the following voluntary assistants, all graduates of the engineering schools named, each of whom took his turn reading the galvanometer, taking notes and applying or weighing off loads: Mr. H. A. Kennicott, Massachusetts Institute of Technology; Mr. F. G. Skinner, University of Michigan; Mr. W. P. Rothrock, Pennsylvania State College; Mr. W. S. Huntington, University of Iowa; Mr. J. T. Richards, University of Wisconsin; Mr. Frank McIntyre, Minnesota State University.

All of the above, with the exception of Mr. McIntyre, who is instructor in physics in one of our High Schools, are engaged on structural iron work.

Respectfully yours,

C. A. P. Turner.

Minneapolis, Minn., Oct. 15, 1898.

THE NEW FREIGHT YARD OF THE HARLEM TRANSFER CO., OF NEW YORK.

One of the most unique freight yard arrangements which we have ever seen, has been adopted in constructing the new terminal freight yard of the Harlem Transfer Co., in New York city. This company was formed to establish a railway freight house shown in the plan has a car frontage of eight cars with an average actual length of 240 ft., corresponding to six cars. Further, it will be noticed, that by placing the car delivery doors on the outside circle and the wagon delivery doors on the inside circle considerable space is saved. Only one freight shed has been built so far, but it will be seen that the plan allows for the construction of a second exactly similar in all respects, should the traffic demand it.

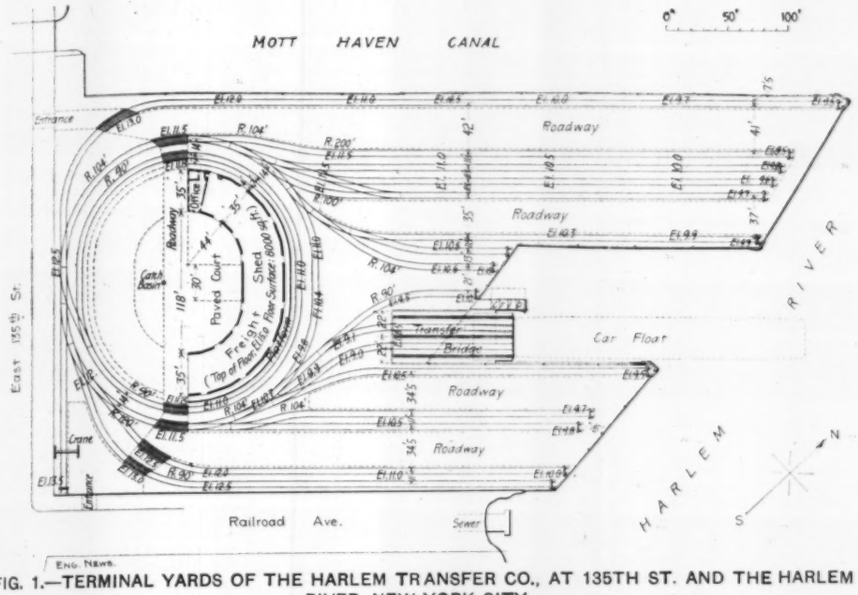


FIG. 1.—TERMINAL YARDS OF THE HARLEM TRANSFER CO., AT 135TH ST. AND THE HARLEM RIVER, NEW YORK CITY.

Walter G. Berg, M. Am. Soc. C. E., Designing Engineer.

For switching operations in the yard a special locomotive, built by the Baldwin Locomotive Works of Philadelphia, Pa., is employed. This

Weight in Working Order:
On driving wheels..86,000 lbs.; Engine, total....86,000 lbs.
Cylinders: Number ..... Two.
Diameter and stroke..... 17 x 24 ins.
Diameter of barrel, inside smallest ring .....4 ft. 6 "
Thickness, barrel plates ..... 9-16-in.
Working steam pressure ..... 180 lbs.
Firebox:
Length, inside, 5 ft. 9⅞ ins.; width, inside ...3 ft. 5⅜ ins.
Depth at front, 4 " ¼ " ; depth at back, ..3 " 9¼ "
Thickness, side plates, ⅜-in.; back plate ..... ⅜-in.
" crown " ½-in.; tube plate, ... ½-in.
Tubes: Number 191
Diameter, outside ..... 1¾ ins.
Length over tube plates ..... 8 ft. 3½ ins.
Heating Surface and Grate Area:
Heating surface, tubes (interior area)..... 718.03 sq. ft.
" " firebox ..... 80.11 "
" " total ..... 798.14 "
Grate area ..... 20.2 "

For the information from which this article has been prepared we are indebted to Mr. Walter G. Berg, M. Am. Soc. C. E., Assistant Engineer, Lehigh Valley Ry., Jersey City, N. J., who designed the terminal, and to the Baldwin Locomotive Works.

NOTES FROM THE ENGINEERING SCHOOLS.

Cornell University.—The address by President Schurman at the 30th annual commencement, June 16, 1898, entitled "A Generation of Cornell," has been printed in a handsome pamphlet with red line borders and broad margins by G. P. Putnam's Sons, New York city. The address covers the history of Cornell from 1868 to 1898, and a remarkable history it is; that of modest beginning, of struggle for life, of weary years of waiting, and then of rapid progress to the proud position the University now holds, that of being one of the leading universities of the world. The address is worthy of preservation by every Cornellian, and by all who are interested in American educational history.

We have also received a pamphlet containing the sixth annual report of President Schurman, 61 pages, with an appendix of 100 pages, giving the reports of the deans of faculties, the register, librarian, etc.

Massachusetts Institute of Technology.—An illustrated descriptive circular, issued by the department of mechanical engineering, gives, among other things, tables showing the present occupation of all graduates of the department since 1868. There are 389 living graduates of the department of mechanical engineering, and but four of these are unaccounted for. Definite occupations are stated for the balance. Over 90 per cent. are employed in work for which they received special training at the Institute, and most of the remainder are engaged in pursuits demanding some scientific training. The Institute has established a spe-

freight receiving and delivery station for the Harlem River district of the city, and for this purpose it secured the city block at 135th St. and the Harlem River, 330 x 540 ft. in size, the narrower side fronting on the river. This property had been bulkheaded in at various times in the past, and had a slip 100 ft. wide and 200 ft. long. The problem which the engineer was called upon to solve was to develop the property for receiving and delivering freight, either in car loads or in separate packages, the cars to be transferred to and from the various railway terminals in and about the city by the regular car transfer floats.

The first step was to construct a transfer bridge at the head of the slip. As the standard transfer float adopted by the company was 35 ft. 6 ins. x 240 ft. in size, in order to keep the outer end of the boat when tied up to the bridge within the bulkhead limits, the shore end of the bridge had to be placed within 280 ft. of the line of 135th St., thus limiting the track system to an area of about 280 x 330 ft. The transfer bridge itself is a three-truss wooden bridge, 100 ft. long, the shore end resting on piles and the sea end on a wooden pontoon 40 x 38 x 8 ft.

The leading feature of the design (Fig. 1), however, is the full circle distributing track, from which all side and switching tracks start, and the radial freight house with the inside courtyard for teams. The freight house is an iron frame single story building, 35 ft. wide, on brick piers, and is sheathed with corrugated iron and roofed with tar, felt and gravel. It will be noticed that the loading and unloading track for the freight house is inside and concentric with the circular distributing track, to which it is connected by a switch track. Among the features of this radial or annular form of freight house which the engineer will notice particularly is the great track frontage for a given floor space. Thus the half circle

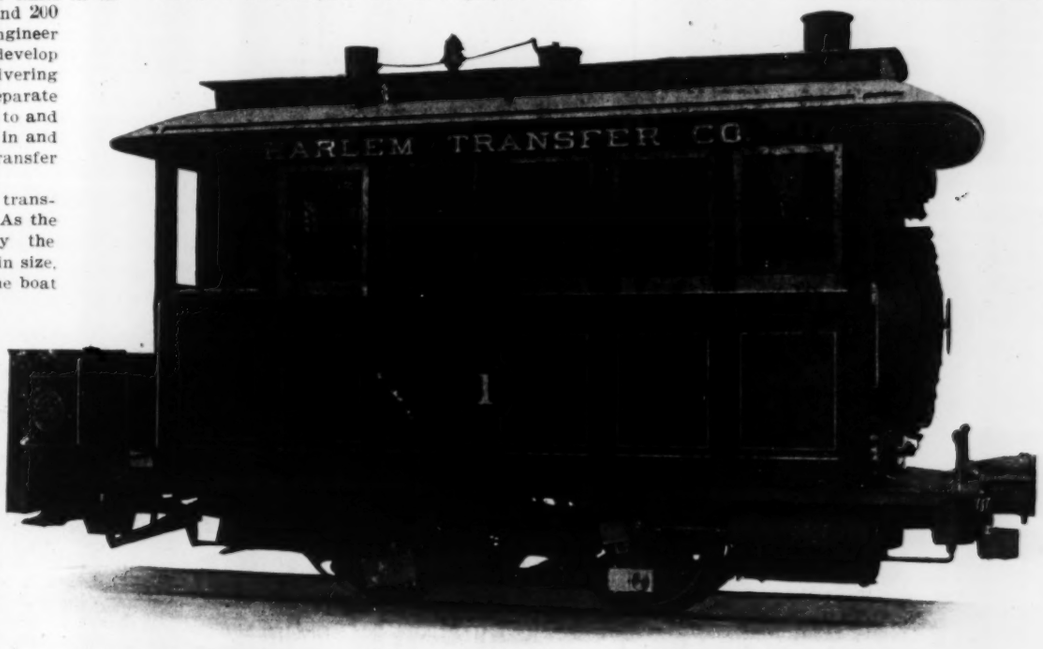


FIG. 2.—FOUR-COUPLED SWITCHING LOCOMOTIVE FOR THE HARLEM TRANSFER CO.

Baldwin Locomotive Works, Philadelphia, Pa., Builders.

engine is shown by the accompanying cut, Fig. 2, and its leading dimensions and particulars are as follows:

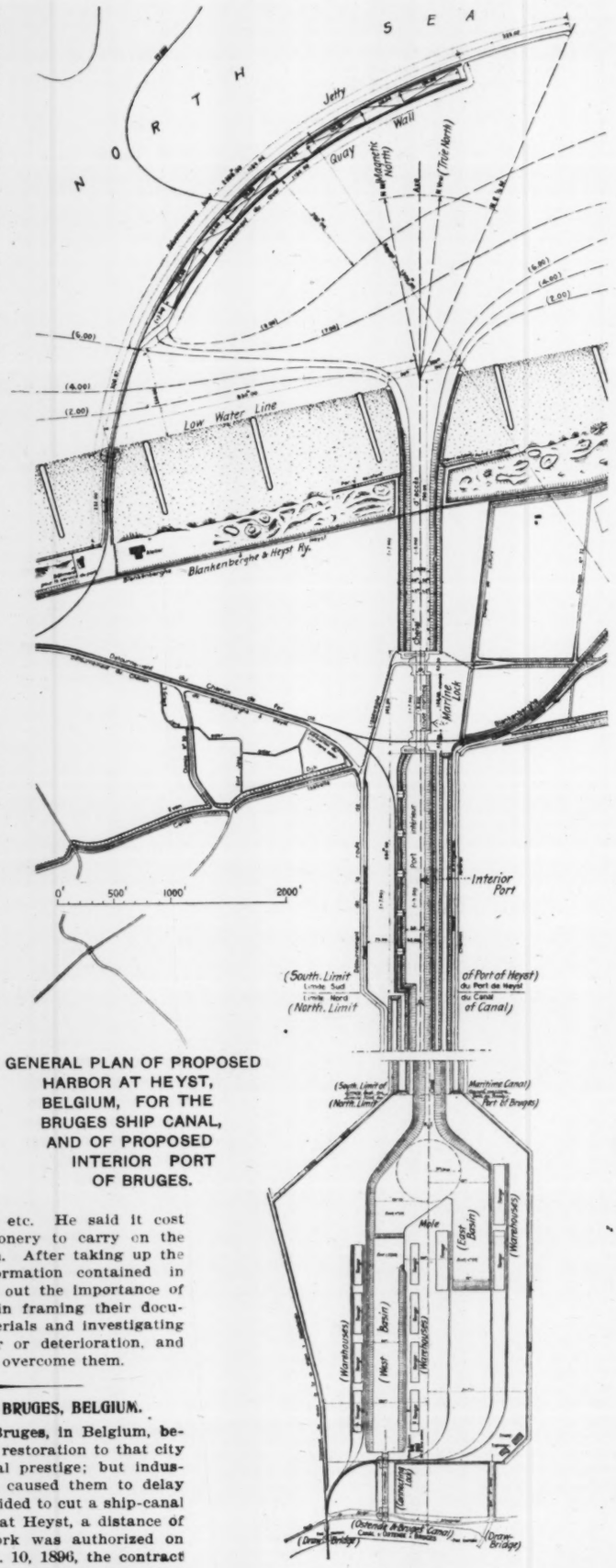
Switching Engine; Harlem Transfer Co., New York, N. Y.
General Description: Class of traffic.....Switching.
Gage of track..4 ft. 8½ ins.; Fuel.....Hard coal.
No. of driving wheels.....4; No. of truck wheels...None.
Simple or compound .....Simple.
Running Gear:
Driving wheels, No.....4; Diameter.....3 ft. 8 ins.
Wheelbase: Driving .....6 ft. 6 "

cial course in architectural engineering, offered as an option in the course in architecture. This course is to meet the demands created by the development of steel construction in the last ten years, and the course is adapted to the solution of the many new and difficult problems thus presented to engineers and architects.

Lehigh University.—An address on "Origins and Destiny," delivered on Founder's Day, Oct. 13, 1898, by Langdon C. Stewardson, Chaplin of the University, has been printed in pamphlet form. It is a highly philosophical and somewhat metaphysical discourse, but is interesting reading, and contains many good thoughts well expressed. It has some thoughts on "science," however, which seem rather to belong to the philosophy of the Keely motor than to the science of ordinary mortals, such as the following:

> It is not Phillip Brooks, but Professor Brinton who says, "The teachings of the severest science tells us that matter is in its last analysis motion, and that motion is naught else than mind; and who dare deny that in their unconscious functions our minds may catch some overtones, as it were, from the harmonies of the Universal Intelligence, thus demonstrated by inductive research, and vibrate in harmony therewith?"

Purdue University.—"The Relation of Chemistry to Railroads" was the subject of the opening lecture in the University course, delivered by Dr. Charles B. Dudley, Chief Chemist of the Pennsylvania R. R. Co. In connection with the amounts of money expended by railways for materials, he said the Pennsylvania Railroad spent from $17,000,000 to $20,000,000 annually on this account. Of this aggregate, about $5,000 was expended for rubber-bands, $7,000 for lead pencils, $1,000 for pins, $5,000 for ink, $2,000 for toilet soap, $1,000,000 for lumber, $60,000 for hose, etc. He said it cost nearly as much for stationery to carry on the business as it did for iron. After taking up the specifications and the information contained in them, Dr. Dudley pointed out the importance of the duty of the chemist in framing their documents and in testing materials and investigating difficult problems of wear or deterioration, and the suggestion of means to overcome them.



GENERAL PLAN OF PROPOSED HARBOR AT HEYST, BELGIUM, FOR THE BRUGES SHIP CANAL, AND OF PROPOSED INTERIOR PORT OF BRUGES.

THE SHIP CANAL OF BRUGES, BELGIUM.

In 1877 the citizens of Bruges, in Belgium, began to plan means for the restoration to that city of its one-time commercial prestige; but industrial and other conditions caused them to delay until 1890, when it was decided to cut a ship-canal from Bruges to the coast, at Heyst, a distance of about six miles. The work was authorized on Sept. 11, 1895, and on Jan. 10, 1896, the contract for its execution was let to the Campagnie des Installations Maritimes de Bruges. From a pamphlet issued by this company for the International Congress on Navigation, held this year at Brussels, the following description of the canal is abstracted:

The port of call at Heyst is made up of a jetty, alongside of which ships can lay; an anchorage and protected harbor, a canal with a marine lock and an interior basin with docks. The jetty leaves the shore about half way between Heyst and Blankenberghe, and forms a curve with radii of 3,936 and 6,560 ft., and at the end the direction is about parallel with the coast line and 2,788 ft. distant at low tide. This jetty has in it an opening, extending 984 ft. beyond low-tide mark, intended to facilitate the movement of the shore currents and prevent the deposit of silt and sand in the harbor. Over this opening a railway is carried on a steel trestle structure with bents 16.4 ft. apart, and this bridge terminates at an abutment of masonry founded by the aid of compressed air.

The outer part of this jetty is a solid curved structure, protected by a high sea-wall. The base of this portion is made of monoliths of beton weighing from 2,500 to 3,000 tons, deposited in iron caissons, each 82 ft. long and 29.6 ft. wide and of a height varying with the depth of the water. They rest upon a sand bottom previously dredged to a depth of about 13 ft., and the tops of the caisson blocks rise to a height of about 3.28 ft. above low-tide. Upon this base is built a wall of 50-ton concrete blocks; this wall being 16.4 ft. thick and 24 ft. high above low-tide mark; an outer parapet wall, 3.28 ft. high, protects the top of the jetty. The jetty terminates in a pier-head, 50 ft. in diameter, upon which a lighthouse and the fog siren are established. Under the shelter of this jetty, and at a distance 177 ft. between centers, is built a parallel quay wall, having a total length of 3,562 ft., and constructed in a similar manner, of 3,000-ton foundation caissons surmounted by a wall of 50-ton blocks. The space between these walls forms a quay, upon which are railways, warehouses, cranes, etc., for the rapid handling of goods at this port of call. Inside this quay there is a depth of water of 26.24 ft. at low-tide over a space of 984 ft. wide.

From this harbor a dredged channel 2,460 ft. long, leads to the sea-lock, or entrance to the ship-canal. This channel has an opening 656 ft. wide, a normal width of 164 ft. on the bottom, and a depth of 19.68 ft. at extreme low tide. The lock is 65.6 ft. wide and 518.24 ft. long between gates and 839.7 ft. long over all. The gates roll into opening built at right angles to the axis of the lock proper, and the lock can be closed or opened in 10 minutes. Electricity is used to operate the gates, cranes, etc., and to light the harbor; and a central station, equipped with 500-HP. boilers and engines and two generating dynamos, will provide all the power now necessary. Before completion this port will also be furnished with a repair shop, a floating crane of 55-ton capacity and a large marine dredge.

The so-called interior port of Bruges commences at the inner end of the lock and includes two basins parallel to the canal axis and separated by a mole 393 ft. wide. The West Basin is 1,771 ft. long and 21.3 ft. deep; the East Basin is somewhat shorter, and is 26.24 ft. deep, and both basins have a surface width of 295 ft. At the shore end of the West Basin is a lock uniting the new port with the Ostend canal system. This lock is only 39.4 ft. wide and 564 ft. long over all, and has a depth of 14.7 ft. over the sill. Warehouses will be built upon the central mole, and movable cranes, of 3,000 lbs. capacity, will command the whole length of the dock front.

Progress upon this work, to the present date, is reported upon as follows: The work was ordered on Sept. 11, 1895, and was to be completed in seven years, or on Sept. 11, 1902. The Campagnie des Installations Maritimes de Bruges, which obtained the contract, has a capital of 9,000,000 francs, and is itself interested in the completion of the work, as the following statement of cost and capital contributed shows:

	Francs.
Construction company interest	6,900,000
State of Belgium	26,810,620
Province of West Flanders	2,000,000
City of Bruges	3,258,446
Total	38,969,075

The City of Bruges actually contributes more than appears in the above statement, as it owns one-half, or 4,500,000 francs, of the capital of the construction company. The contractors are themselves interested to the extent of 3,500,000 francs, and the West Flanders railways and

TRANSVERSE SECTION OF PROPOSED SHIP CANAL CONNECTING THE HARBORS OF HEYST AND BRUGES, BELGIUM.

some Bruges manufacturers have contributed altogether 1,000,000 francs. At the present time the work is being actively pushed. The ship canal is diked, and is now being dredged out; the interior port is being cleared for the excavators; but the most active work is at the jetty and port, and it is expected that both the jetty and the sea-lock will be finished in 1899. The publication from which this is taken does not enter into details of jetty or lock construction.

THE SOFTENING OF WATER BY THE ARCHBUTT-DEELEY PROCESS.*

By Leonard Archbutt.†

Hard water owes its peculiarities to the presence of compounds of lime and magnesia, chiefly the carbonates and sulphates, but occasionally also the chlorides and nitrates.

Distilled water, from which every trace of carbonic acid has been expelled by boiling, can hold in solution only about 1.3 grain of carbonate of lime per gallon; but if the water be saturated with carbonic acid it can dissolve as much as 60 to 70 grains, the whole of which, except the above 1.3 grain, is precipitated when the water is boiled and the carbonic acid expelled. All natural water contains carbonic acid, and therefore all such water which has been in contact with chalk contains carbonate of lime in solution.

The use of slaked lime, or hydrate of lime, for softening chalk water‡ was first proposed by Thomas Henry, F.R.S., about a century ago. The lime removes from the water the dissolved carbonic acid, combining with it to form carbonate of lime, which precipitates, and the carbonate of lime previously held in solution by the carbonic acid precipitates also, leaving the clear water soft. The late Dr. Thomas Clark, of Aberdeen, in his celebrated patent in 1841, described the method of ascertaining the necessary amount of lime by determining the alkalinity of the water; and also the method of controlling the process on the large scale by the simple and delicate test with nitrate of silver, which indicates, by the brown color of the precipitated silver oxide, when the slightest excess of lime has been added. This test fails, however, where, as occasionally happens, the water contains sulphuretted hydrogen. Clark's process in its simplest form is perfectly applicable to but few waters, namely, to those only of which the hardness is due entirely to chalk. It also requires large and expensive settling tanks to carry it out unless filters are employed.

Carbonate of magnesia, though much more soluble in water than carbonate of lime, is usually met with in smaller proportion, seldom exceeding, according to the author's experience, 5 or 6 grains per gallon. Occasionally he has found 10 or 11 grains; and in one instance the exceptional quantity of 28.8 grains per gallon. Carbonate of magnesia can easily be removed from water by treatment with lime; but as it is much more soluble than is usually supposed in water quite free from carbonic acid, merely adding enough lime to remove the carbonic acid will not suffice; it is necessary to add a sufficient excess of lime to decompose the carbonate of magnesia and convert it into hydrate of magnesia which is almost insoluble in water; thus

$$Mg\ CO_3 + Ca\ (OH)_2 = Mg\ (OH)_2 + Ca\ CO_3$$
(insoluble precipitate).

As magnesia reacts like lime with a solution of nitrate of silver, this test does not show when sufficient lime has been added to decompose the whole of the carbonate of magnesia; and it is partly on this account that, when such waters are treated by Clark's process, the removal of the carbonate of magnesia is frequently incomplete. There is also another reason. Magnesia, when set free by lime water, has a tendency to remain in a state of semi-solution, forming an opalescent liquid which may be kept for several days, and even heated, without the magnesia precipitating; and when an attempt is made to filter water in this condition, the magnesia separates out as a gelatinous precipitate in the pores of the cloth, completely choking them. On account of this, the softening of water containing both carbonate of lime and carbonate of magnesia is frequently limited to the removal of the carbonate of lime; and the carbonate of magnesia is purposely left in the water. Owing to the practical impossibility of filtering out the magnesia, the hardness of the water can be reduced only from 18.5° to 10° or 12°;‖ but it has been proved by experiment that by doubling the quantity of lime, and precipitating in plain tanks by the special method about to be described, the extra hardness can be further reduced to 6°, and the extra cost for lime is balanced by the saving in the cost of filter cloths, etc.

Sulphate of lime, or calcium of sulphate, which is one of the most objectionable constituents of boiler water on account of the hard crystalline scale it produces, does not owe its solubility to the agency of carbonic acid, but is dissolved by the water itself. It is an exception to the general rule that hot water dissolves more of a substance than cold water. The solubility, it is true, increases from 32° F. up to about 104° F.; but above this temperature it diminishes, at first slowly, then rapidly, and finally more slowly again, as shown by the following Table I., and the diagram Fig. 4:

Table I.—Solubility of Sulphate of Lime in Pure Water.

Observer.	Temperature. deg. F.	Corresponding pressure above atmosphere per square inch. lb.	Sulphate of lime (anhydrous) dissolved by 1 gallon of pure water. grains.
Marignac*	32.0	..	133.0
	68.0	..	144.2
	104.0	..	149.8
	140.0	..	145.6
	176.0	..	136.5
	212.0	0	121.8
Tilden and Shenstone†	284.0	37.8	54.6
	324.5	80.8	39.2
	356.5	132.0	18.9
	473.0	513.5	12.6

It is commonly stated, apparently on the authority of Sullivan,† that sulphate of lime is quite insoluble in water at a temperature of 302° F., equivalent to a boiler pressure of 55 lbs. per sq. in.; but Tilden and Shenstone's experiments in Table I. show that even at 473° F., a temperature far beyond the range of any ordinary steam boiler, pure water can retain in solution 12.6 grains of sulphate of lime per gallon. The solubility of sulphate of lime in natural water is influenced by the presence of other substances with which it is associated. Thus it is increased by the presence of common salt; but the amount dissolved by the salt water diminishes as the temperature is raised. At 437° F., however, a solution containing 21 parts of common salt to 100 of water can still retain in solution 0.178 part of sulphate of lime, or 124.6 grains per gallon.‡ In saturated brine Lewes states that sulphate of lime is insoluble. Sulphate of soda is said to increase the solubility of sulphate of lime. Chloride of calcium, on the other hand, diminishes it, but does not reduce it to nil until the proportion of 50 chloride of calcium to 100 water is reached. Chloride of magnesium increases the solubility at the ordinary temperature, but at higher temperatures appears to behave similarly to calcium chloride.

This point has been dwelt upon, because there is a certain class of apparatus, sold for preventing scale in steam boilers, which depends for its usefulness upon the supposition that the carbonate and sulphate of lime are rendered insoluble by the mere heating of the feed water; but so far as the sulphate is concerned, Tilden's experiments prove that such apparatus cannot be efficient, especially that kind in which the feed water is passed into the boiler through a tube in the steam space, where the water occupies only a few minutes in its passage through the tube. What happens in a steam boiler, working at, say, 140 lbs. pressure, is probably as follows: The water containing, say, 5 to 10 grains per gallon of sulphate of lime, besides carbonate, first loses its carbonic acid and deposits the carbonate of lime, partly as mud and partly as scale; the water then concentrates by evaporation, until the sulphate of lime reaches the saturation point; and then the sulphate of lime gradually crystallizes out, mainly upon the plates, cementing the carbonate of lime into a hard scale, so long as the evaporation continues.

To suppose that by merely heating the water under pressure, without concentration, the sulphate of lime is entirely thrown down, is contrary to the results of Tilden's experiments; and it is doubtful whether even the carbonate of lime is more than partially precipitated under these conditions, unless the water is actually boiled sufficiently to expel the carbonic acid.

As the solubility of the sulphate of lime in water does not depend upon the presence of carbonic acid, this salt is not precipitated when the carbonic acid is removed by the lime treatment. Before sulphate of lime can be removed, it must be decomposed, which can be done by adding sodium carbonate, when the following reaction occurs:

$$Ca\ So_4 + Na_2\ CO_3 = Ca\ CO_3 + Na_2\ SO_4;$$

The sulphate of lime is decomposed, carbonate of lime is precipitated, and sulphate of soda remains in solution. In this case there is not a diminution but a slight increase in the total solids, 136 parts of sulphate of lime being replaced by 142 parts of sulphate of soda.

In removing the "permanent hardness"—that is, the hardness due to the sulphates and other compounds of lime and magnesia, these compounds are not precipitated unchanged, but are replaced by other salts of a less objectionable and more soluble character, and the dissolved solids are slightly increased. Such softened water, therefore, should not, any more than unsoftened water, be allowed to concentrate indefinitely in steam boilers, but should be regularly blown off and replaced by fresh water from time to time; or the boilers should be completely emptied at regular intervals of not too long duration. If this be done, no trouble will be experienced; but if the water be allowed to concentrate too far, priming may occur, and even scale may be formed.

Chloride and nitrate of calcium, which are sometimes met with in hard water, are very soluble salts, which do not enter into the composition of boiler incrustation. They are decomposed by sodium carbonate similarly to calcium sulphate; the calcium is precipitated as carbonate, and sodium chloride and nitrate remain in solution.

Sulphate, chloride and nitrate of magnesium are also easily soluble salts, which are not constituents of ordinary boiler incrustation. Sulphate of magnesia may nevertheless prove a highly objectionable substance, if allowed to concentrate in the boiler. A soft carbonate of lime incrustation, when boiled with a solution of sulphate of magnesia, is gradually transformed into sulphate of lime and basic carbonate of magnesia, which latter, if the temperature be high enough, changes into hydrate of magnesia, and the two together then form a hard scale like porcelain, thus:

$$Ca\ CO_3 + Mg\ SO_4 + H_2O = \underbrace{Ca\ SO_4}_{\text{hard scale}} + Mg\ (OH)_2 + CO_2.$$

Chloride and nitrate of magnesium are objectionable, owing to their corrosive character. The hardness caused by either of the above compounds of magnesium can be removed by adding to the water caustic soda, or, what comes to the same thing and is cheaper, lime and carbonate of soda in proper proportions, by which these magnesium compounds are decomposed and the magnesia is precipitated as hydrate. When caustic soda is used, the reaction is

$$Mg\ SO_4 + 2\ Na\ OH = Mg\ (OH)_2 + Na_2\ SO_4.$$

and when lime and carbonate of soda are used

$$Mg\ SO_4 + Na_2\ CO_3 + Ca\ (OH)_2 = Mg\ (OH)_2 + Ca\ CO_3 + Na_2\ SO_4.$$

Thus, all hard water can be softened by means of either lime alone or lime and sodium carbonate, in proportions which depend upon the character of the water to be treated; but a water may be so hard as to be unsuitable for softening, owing to the cost of the chemicals required and the excessive proportion of soluble salts remaining.

Carbonating Softened Water.—Hard water is, as a rule, an extremely dilute solution of the substances which it is wished to remove from it; and the changes which occur when it is chemically softened require time for their completion. These changes are both more rapid and more complete if the hard water and reagents are heated together, than if they are mixed when cold; and water which has been softened when cold is liable to deposit a further small quantity of precipitate on heating. At Derby several years ago, during the experimental softening of water for use in some of the stationary boilers in the locomotive works*, it was found that the softened water which formed no scale in the boilers had quite the opposite effect in the injectors, feed pipes, and valves. The valves began to give trouble by sticking, and an examination proved that the whole interior of the feed apparatus was coated with a soft deposit, which was gradually choking everything. Some of the deposit removed from the interior of one of the copper pipes gave the following results on analysis:

Carbonate of lime	42.58
Carbonate of magnesia	3.33
Hydrate of magnesia	24.87
Silica	11.05
Alumina	3.68
Peroxide of iron	2.23
Water and organic matter	10.79
Metallic copper (from the pipe)	1.47
	100.00

*Paper read before the Institution of Mechanical Engineers.

†Chemist of the Midland Ry., Derby, England.

‡The term "chalk water" is uncommon in the United States. It means water containing carbonate of lime which has been dissolved from what are called the "chalk" formations in England.—Ed. Eng. News.

‖One degree of hardness is caused by 1 grain of carbonate of lime dissolved in 1 gallon of water.

*Annales de Chimie et de Physique (5), I., page 274.

†Philosophical Transactions, Part I., 1804.

†British Association Reports, 1859, page 292.

‡Tilden and Shenstone, "Proceedings of the Royal Society," vol. xxxviii. (1885), pages 331 to 336.

*Journal of the Society of Chemical Industry, vol. x. (1891), page 515.

The large amount of magnesia in this deposit, and the fact that carbonate of lime and hydrate of magnesia occur in it in proportions which are chemically equivalent, whilst in the water itself the ratio of magnesia to lime was much less, afforded a clue which was followed up by heating some of the clear softened water in a glass flask to about 200° F. Nothing appeared to separate at first, but on shaking the water around in the flask an exceedingly thin film peeled off the surface of the glass, and broke up into fragments which floated about in the water. These fragments were found to consist of carbonate of

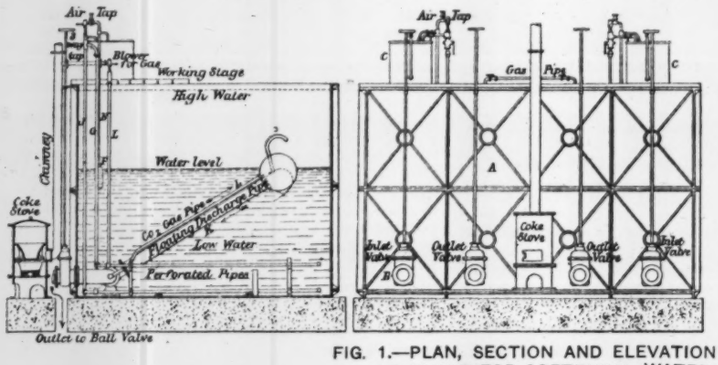
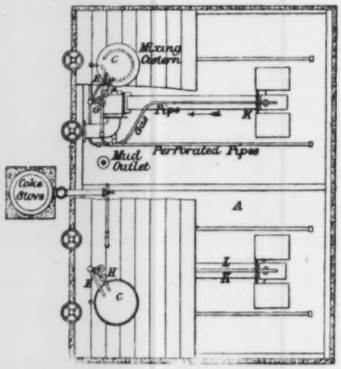


FIG. 1.—PLAN, SECTION AND ELEVATION OF PLANT FOR SOFTENING WATER.



lime and magnesia. The cause of the deposit was now apparent. The chemical reaction between the lime and the carbonate of magnesia,

$$Mg\ CO_3 + Ca\ (OH)_2 = Mg\ (OH)_2 + Ca\ CO_3,$$

which was not quite complete in the cold, completed itself when the hot water became raised in temperature in the hot pipes, and a slight further precipitation took place. If thrown down in the boilers, this would have amounted to nothing more serious than a little harmless mud; but by its precipitation in the feed pipes the narrow passages were gradually choked up. The experiment was subsequently made of passing a little carbonic acid into some of the clear softened water before heating, and this was found entirely to prevent further precipitation at 200° F. The remedy, therefore, lay in carbonating the softened water; and eventually a coke stove was set up, and the gases from it were led into the softened water in sufficient proportion to convert all the carbonates into bicarbonates, which is easily ascertained by means of phenolphthalein solution. Since then no further troubue has been experienced.

Passing carbonic acid into the clear softened water cannot possibly harden it, as some appear to think. After removal of the carbonate of lime, as much carbonic acid as desired may be put back into the water without hardening it. Carbonating the softened water is, in fact, an advantage, not only when the water is required for feeding boilers, but for some other purposes, such as wool-washing and tanning, because all traces of free caustic alkali and carbonate of soda remaining in the softened water, which would be detrimental, are converted into bicarbonates. By this process softened water is made more palatable for drinking, and the tendency to form a deposit in town mains is lessened, if not entirely obviated.

Softening Apparatus.—The mechanical operations involved in the softening and purification of hard water include the preparation of the reagent, the mixing of it with the hard water, the separation of the precipitate, and the subsequent bicarbonating of the softened water. The apparatus and process employed must be of the simplest possible character compatible with efficiency, and should be applicable to the removal of both temporary and permanent hardness, whether due to lime or to magnesia salts. Nothing could be simpler than the original Clark process of precipitation in plain tanks; but the slow settling of the precipitate necessitated either large and costly tanks or the use of filters; and filtration, besides complicating the process, has been found to be troublesome and expensive when the water contains magnesia, and practically unworkable if any attempt be made to remove the magnesia. In the process about to be described plain tanks are used and filters are dispensed with; for by a special method of manipulation it has been found possible to increase the rate of subsidence of the precipitate to such an extent that about one-eighth of the tank area required in Clark's process is often sufficient. This effect is produced mainly by the simple expedient of stirring up, every time a tankful of water is softened, some of the precipitate which has settled from previous operations. This precipitate by lying at the bottom of the tank becomes aggregated into coarse flakes, which, when stirred up and allowed to settle again, carry down the fine particles of fresh precipitate so rapidly that in from half an hour to an hour, the water clears itself to such an extent that the suspended matter remaining, even at a depth of 6 ft. from the surface, does not exceed about 1 grain per gallon. This very small quantity may for many purposes be neglected; and when perfectly clear water is required the subsequent carbonating redissolves it, hardening the water, it is true, to the extent of one degree or less, according to the amount in suspension, but not sufficiently to be of material importance.

Fig. 1 shows the general arrangement of apparatus suitable for treating on this principle from 5,000 to 10,000 gallons of water per hour. The two exactly similar softening tanks A A, preferably 10½ ft. deep, are intended to be used alternately, one being filled with water which is being softened and clarified, whilst a supply of purified water is being drawn off from the other tank. For 4,000 gallons per hour, or less, one softening tank is sufficient, with a storage tank; for more than 12,000 gallons per hour three tanks are desirable, and for 35,000 gallons and upwards, four tanks. The working capacity of each softening tank is three-fourths of its depth, about 2½ ft. of water and mud being allowed to remain when the water is drawn off, while a margin of 6 ins. at the top is left in filling, which is done by means of the supply pipe B. The quantity of water to be treated being thus exactly known, the proper quantities of quicklime and anhydrous carbonate of soda—58% alkali—are weighed out. The lime is first slacked in hot water in one of the small reagent tanks CC, Figs. 1 and 2, which is filled with water, either from a tap connected with the softened water main, or direct from the softening tank, by means of the tee and pipe between the three-way tap and blower, Fig. 2, by throttling the passage through the three-way tap, turning on steam to the blower, and opening the tap E, Fig. 2; water is then lifted into the tank through the rose F, Fig. 1. The water is boiled by a steam coil, Fig. 2. After the lime has been completely slacked, the alkali is added, and the liquid is boiled for a few minutes and stirred until the alkali is dissolved. The reagent thus prepared is injected into the hard water in the softening tank through the upper row of horizontal perforated pipes, Fig. 1, in the following manner: Steam at not less than 45 lbs.—preferably 90 lbs.—pressure is admitted to the blower, and the three-way tap is turned so that a current of water is established from the softening tank, through the rose F, Fig. 1, the suction pipe N, Figs. 1 and 2, and a three-way tap, down the vertical pipe G, and back into the tank, through the perforations on the upper side of the upper row of horizontal pipes. Into this current of water the reagent solution is slowly admitted by opening the tap H, Fig. 2, and is diffused throughout the volume of hard water in the softening tank. The operation including the rinsing of the reagent tank, is generally allowed to occupy ten minutes. The suction pipe in the reagent tank extends below the perforated false bottom O, Fig. 2, which prevents any pieces of stone, etc., in the lime from getting into the pipe. The tap H having been shut off, the air-tap over the blower opened, and the three-way tap reversed air is forced down the pipe J, Fig. 1, and through the perforations in the under side of the lower row of pipes, into the mud at the bottom of the tank, stirring up a portion of the mud and diffusing it through the water. After the blower has been in operation for a few minutes—usually ten, but varying with different waters—the steam is shut off, and in about an hour or less the water will be ready to be drawn off. The operations of carbonating and drawing off are effected simultaneously by means of a floating discharge pipe K, Figs. 1 and 3, the body of which is of brazed copper, rectangular in section, having at intervals along the bottom, baffles, which cause the water to flow down in a cascade and splash up into the gases, which are injected from the coke stove into the cast-iron head of the pipe through the gas pipe L. The water and surplus gas escape together, at the lower end, through a ball valve, the carbonated water falling into the cistern from which it is drawn for use, and the gas escaping into the air. The coke stove, Fig. 1, contains a supply of coke in the upper part, which, by falling through the cone, maintains a fire of constant thickness about 12 ins. in depth over the firebars. The top of the chimney, Fig. 1, is closed by a butterfly valve, below which the gas is drawn off through a branch for carbonating. In order to ensure a constant and ample supply of gas, a small blower is fixed in the branch pipe. When the ball valve closes and water ceases to flow down the discharge pipe the gas accumulating in the head of the pipe forces the water below the sill M, and escapes through the pipe N without disturbing the water in the tank. When the ball valve opens again the floating pipe first empties itself of water, and the gas then escapes through the ball valve, relieving the pressure, and allowing water again to pass over the sill and down the pipe with the gas, so long as the valve remains open.

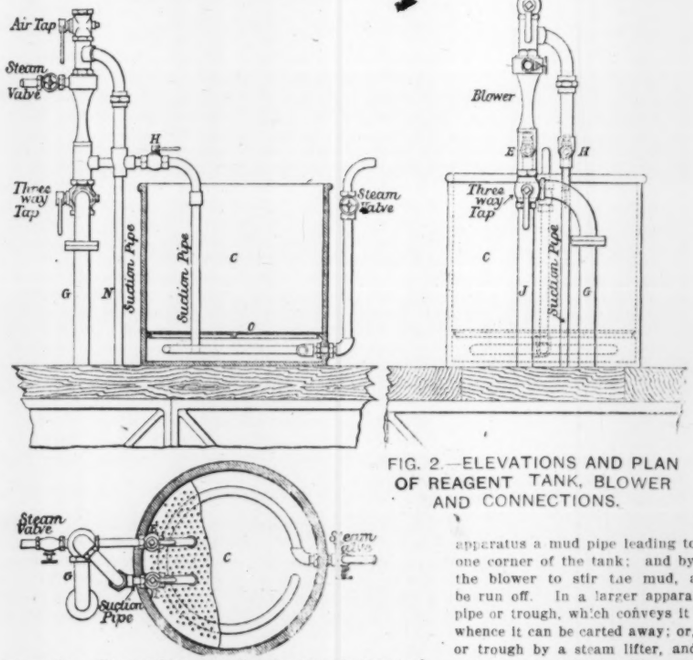


FIG. 2.—ELEVATIONS AND PLAN OF REAGENT TANK, BLOWER AND CONNECTIONS.

The precipitate is prevented from unduly accumulating in the tanks by its partial removal at regular intervals; this is effected in various ways to suit different circumstances. From the nature of the precipitate, and the fact that it is not allowed to consolidate, it is easily dealt with. In a small apparatus a mud pipe leading to a drain is provided near one corner of the tank; and by lifting a plug, and using the blower to stir the mud, a sufficient quantity can be run off. In a larger apparatus it is swept out into a pipe or trough, which conveys it into shallow draining pits, whence it can be carted away; or, it is raised from the tank or trough by a steam lifter, and discharged direct into a cart or wagon lined with waste furnace ashes, through which the excess of water soon drains, leaving the nearly dry mud and ashes ready for tipping.

General Remarks.—The softening of water is an exact process, and in order to obtain satisfactory results proper attention must be given to it. Rough-and-ready methods may succeed in a few instances, but they will not answer in the long run for general adoption. Automatic machines for softening water, which are said to require attention only once or twice a day, and which run continuously, are not to be recommended. In the comparatively rare cases where lime alone is required, and the hard water is practically invariable in character, the continuous method of mixing the hard water with lime water in properly proportioned streams may give good results, provided the machine for preparing the lime water is thoroughly efficient and properly attended to. Lime water is a saturated reagent;

it can be prepared of nearly constant strength by causing water to flow continuously through a mass of it kept in agitation, and the solution being very dilute, does not need extremely fine measurement. But when the same plan is adopted with a solution of caustic soda of much greater strength, finer measurement is necessary; and unless it be carefully looked after, a deficiency or an excess of reagent in the softened water may easily occur. Another objection to the continuous flow system of softening is that, unless frequent tests are made, a large quantity of improperly treated water may pass from the apparatus. Therefore, it is preferable to soften a known volume of water with a known weight of chemicals, and to test each tankful; the excess or deficiency of reagent can then never be serious, even with a variable water. With the tanks fitted as above described, the manipulation of 20,000 or 30,000 gallons of water is as easy as that of one gallon; the appliance for mixing is effective and easily kept in order; every tankful of water may be treated with whatever weight and kind of chemicals are desired, and every drop

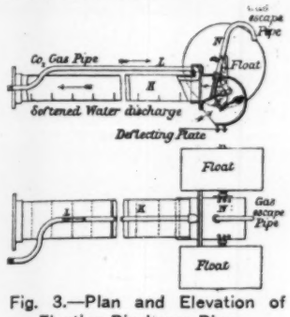


Fig. 3.—Plan and Elevation of Floating Discharge Pipe.

of water gets its proportion. The labor is light. No expensive buildings are required; all that are necessary are a storehouse for lime and coke, and a covered working stage over the tanks; and the apparatus generally is almost indestructible, necessary repairs being limited to keeping the valves in order, occasionally cleaning out the holes in the perforated pipes, and painting the tanks outside; experience shows that they do not rust inside.

This process has been in operation since January, 1892, in the Midland Railway Works, at Derby, clarifying and softening the sewage-polluted water of the river Derwent; reducing the hardness from about 15° to 4½° to 5°, and effecting considerable organic purification, at an inclusive cost for chemicals, labor and interest on outlay, of about 2 cts. per thousand gallons. The water is of variable character. The following analyses recently made show the composition of the water before and after softening:

	Grains per gallon— Unsoftened water.	Softened water.
Carbonate of lime	9.90	2.63
Carbonate of magnesia	0.78	....
Sulphate of lime	3.06	0.17
Sulphate of magnesia	2.89	1.67
Sulphate of soda	0.41	5.10
Common salt	2.56	2.64
Nitrate of soda	0.28	0.28
Silica	0.34	0.34
Water not expelled at 266° F., organic matter, etc.	1.78	1.37
Total	22.00	14.20
Degrees of hardness	15.4	4.14

By using more lime and alkali, the hardness can be reduced to 3°; but as the softened water is used in locomotives, it is found desirable not to reduce it so low.

The organic purification effected is shown by the following figures:

	Water, From pump main as delivered into tanks.	Same after treatment; 30 minutes' subsidence.
Free ammonia (parts per million).	1.15	1.08
Albuminoid ammonia*	0.42	0.28
Oxygen absorbed in 4 hrs. at 80°F.†	0.204	0.108

*Parts per million. †Grains per gallon.

Bacterial Purification.—Of greater importance from a sanitary point of view is the remarkable bacterial purification effected by this process, which the polluted character of the unpurified river Derwent water brings into special prominence. Before treatment the water swarms with a bacteria capable of growing on a gelatine plate; after treatment, few are left in the water. Dr. Percy Frankland showed, several years ago, that the precipitate of carbonate of lime produced in Clark's process carries down about 98% of the organisms contained in the water; the author's own experiments show that the repeated stirring up of the old precipitate does not impair the efficiency of the purification in this respect, even when the mud is swarming with bacteria, as that in the tanks at Derby must be.

Other Applications.—During the last five years this process has been adopted for softening water at upwards of 50 works at home and abroad, including water-works, dye and bleach works, woolen and worsted mills, paper mills, laundries, etc., where the quantities of water treated by it range from 500 to 45,000 gallons per hour. It has been found to be applicable to all kinds of hard water, and gives the best results when magnesia is present, the hydrate of magnesia forming a coarser precipitate which settles more rapidly than pure carbonate of lime.

An interesting example of the application of this process to a public water supply is afforded at the new water-works of Swadlincote and Ashby. The water, which is pumped from a well, besides being very hard, contains in solution a considerable amount of iron, which precipitates on exposure of the water to light and air. This iron is successfully and completely removed, the hardness of the water is reduced from 22° to 23° to an average of 8¼°, and the softened water is bicarbonated, at a total inclusive cost—for chemicals, labor, steam for the blower, coke for carbonating, and interest at 6% on capital and outlay—of 1.6 cts. per 1,000 gallons. Here 2% is allowed for depreciation and 1% for repairs, which is considered ample for such a plant. Lime only is used in softening this water. The presence of the iron, instead of being a trouble, is a positive advantage in the purifying process, as it assists the precipitation, which is remarkably rapid. The tanks are 10½ ft. deep; and 40 minutes after shutting off steam from the blower the water is clear, almost to the bottom of the tank, and ready to be drawn off. The guaranteed output of the plant is 45,000 gallons per hour, or 540,000 gallons per day of 12 hours; this quantity of water is easily softened and purified in four tanks, each having a working capacity of 27,000 gallons. The purified water gives complete satisfaction to the whole of the consumers, and is being largely laid on to works of various manufacturers in the district.

General statements as to the cost of softening water by any particular process must be misleading, because so much depends upon the quantity as well as the character of the water treated. A water of which the hardness is entirely "temporary," that is due to carbonate of lime and carbonate of magnesia, can be softened with lime alone, which costs, per ton, say, £1 or less; but "permanent" hardness, due to sulphate of lime, can be removed only by using alkali, costing at present prices nearly £5 per ton. Less than one pound of lime per thousand gallons of water will remove 10° of temporary hardness; but 1.6 lb. of alkali is required for the removal of 10° of permanent hardness due to sulphate of lime, while sulphate of magnesia is still more expensive to remove. Taking quicklime at £1 per ton, and alkali at £5 per ton, the cost of the chemicals required for softening water is about as follows per thousand gallons:

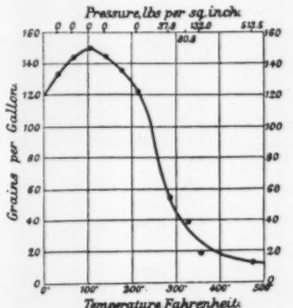


Fig. 4.—Diagram Showing Solubility of Calcium Sulphate in Water at Various Temperatures.

For every 10° of temporary hardness.....0.22 ct.
" " " permanent " .....1.90 cts.

Thus permanent hardness is approximately nine times as expensive to remove as temporary hardness. These figures for the cost of chemicals are quite independent of the particular mechanical process employed, except that caustic soda, which is used in some water softeners, increases the cost. Clark's process is never used for any other purpose than the removal of temporary hardness, and this is why the cost of softening by that process is low. Assuming the cost of labor, interest on outlay, and other incidental expenses to amount to 1 ct. per 1,000 gallons, the cost of softening water of 20° hardness would vary as follows, according to the nature of hardness:

Nature of hardness.	Cost per 1,000 gallons, ct. Chemicals.	Labor, interest, etc.	Total.
All temporary	0.44	1.0	1.44
Half temporary, half permanent	2.12	1.0	3.12
All permanent	3.80	1.0	4.80

Advantages of Softening.—The chief advantage of softening hard water for boilers, apart from the saving of fuel, are increased safety of working, longer life of the boilers, and a great saving in the cost of cleaning and repairs. It has also been found that in a battery of boilers the cost of an extra boiler may be saved, owing to the smaller amount of repairs and to the saving of time required for cleaning. There is no doubt that, to avoid incurring the cost of a softening apparatus, much more money is frequently spent in "boiler compositions" than would pay for properly softening the water. Many of these nostrums are useless, and some dangerous, whilst the best are only a partial remedy for the evils complained of.

Pitting and corrosion of boilers cannot be caused by properly softened water, unless it be allowed to concentrate unduly; neither can the use of such water cause leakage. Corrosion of brass cocks and gage fittings most likely arises from the use of alkali in excess, which is simply due to neglect. Pitting of boilers, even where apparently caused by softened water, may really be due to the uncovering of old "pits" by the removal of scale, which always occurs when softened water is first used in a dirty boiler. Pitting when once started is likely to continue, owing to galvanic action between the metal and the crust of oxide of iron contained in the cavity. By thoroughly scraping the pits so as to remove every trace of this oxide, and by then painting the dry metal surface with a thin coating of mineral lubricating oil, Mr. Deeley has found pitting to cease in many instances when the water was kept slightly alkaline. Leakage of the boiler plates sometimes occurs soon after commencing to use softened water in an old boiler, and is sometimes wrongly attributed to the water; it is really due to the loosening of the old scale, which had covered up defective places.

The softening of water is a necessity in all cases where soap has to be used, as in the washing, milling and scouring of textile fabrics. For such work a great saving may be effected by a properly constructed softening apparatus, without which the softening must be expensively done with soap or soda. The advantage may be judged from the fact that 1,000 gallons of water of only 10° hardness will destroy 12 lbs. of the best hard soap, costing, say, 50 cts.; the same quantity of water can be softened by 1 lb. of lime costing about ⅓ ct., or by 1.6 lb. of alkali, costing rather less than 2 cts., and the soap is saved. One firm state that they save 40% of soap and 25% of alkali by using their own well-water softened from 12° to 3°, instead of using town water of 7° hardness. Several firms testify to the saving of soap in wool washing, and to the improved results obtained by the use of softened water for dyeing, especially where the dyes are applied in neutral or slightly alkaline baths. The material is less liable to fleck, the formation of objectionable lime lakes with the alizarine dyes is avoided, and the colors obtained are more brilliant than when hard water is used. It should not be forgotten that, in any laundry where hard water is used, all the water must be softened in the wash-tub before a lather can be obtained; and this is done at the cost of soap and soda wastefully used, and with all the objectionable lime and magnesia soap scum left in the water.

Clarification of Waste Water.—This process is not limited to the softening of hard water, but has proved very effectual in the clarification of manufacturers' waste water. During the last three or four years apparatus has been supplied for this purpose to about 25 works of various kinds, including bleach and dyeworks, calico-printing works, paper mills, cloth mills, etc., and gives great satisfaction. No novelty of chemical treatment is adopted, but it is found that the thorough method of mixing leads to a great economy of chemicals; and owing to the rapidity of precipitation there is also considerable economy in the amount of tank capacity required. Lime and aluminoferric are the chemicals chiefly used. The clarification of the water is perfect, and when desired the alkalinity of the effluent is neutralized by carbonating. The water is also decolorized.

A TIN-PLATE TRUST was incorporated on Dec. 15 at Trenton, N. J., under the name of the American Tin-Plate Co., with an authorized capital of $50,000,000. The stock is divided into $30,000,000 of common and $20,000,000 of preferred, the latter to pay 7% cumulative dividends.

RULES FOR WORKING IN COMPRESSED AIR were presented to the late International Congress on Internal Navigation by three Austrian doctors, Messrs. Heller, Mager and von Schroetter; they are given as follows in "Le Genie Civil:" They recommend that no work of this character be done under pressures exceeding five atmospheres, or say 75 lbs. per sq. in. The workmen employed should be between 20 and 50 years of age, and should only be acepted after a medical examination into the state of their heart, lungs, vascular system and ears. There should also be medical supervision during the performance of the work. The compressed air should be admitted very gradually; for novices the pressure should not be increased faster than one-tenth of an atmosphere per minute; for trained workmen this rate can be increased to 10 minutes for 1½ atmospheres, 15 minutes for 2½ atmospheres, and 40 minutes for 5 atmospheres. If the renewal of air is well assured during lockage, the capacity of the lock may be 720 liters per man, or, say, 3 to 4 cu. m. for four men. As to the time spent in the working chamber, there is no necessity for limiting it, provided that the pressure is not excessive. It is well to lodge the men near the work and to build special rooms for them at the head of the shaft. The workmen should always dress in woolens to avoid chills.

A FILTER FOR REMOVING OIL FROM FEED-WATER.

A very essential part of the equipment of a surface-condensing steam engine plant, especially in marine service, where fresh feed water is not readily available, is some means of removing from the water of condensation, which is to be used over again as feed water, the lubricating oil which has been carried out of the cylinders by the exhaust steam. In surface-condensing the same water is used over and over again, but the oil, being fed to the cylinders continuously, gradually accumulates in the feed water, and enters the boiler, where it may become a source of danger. A thin film of oil on the heating surface preventing the water from adhering to it, may cause a plate or a tube to be overheated, and possibly cracked, and this danger is greater if the oil makes a thick paste with any mud or fine scale that may happen to be present in the boiler.

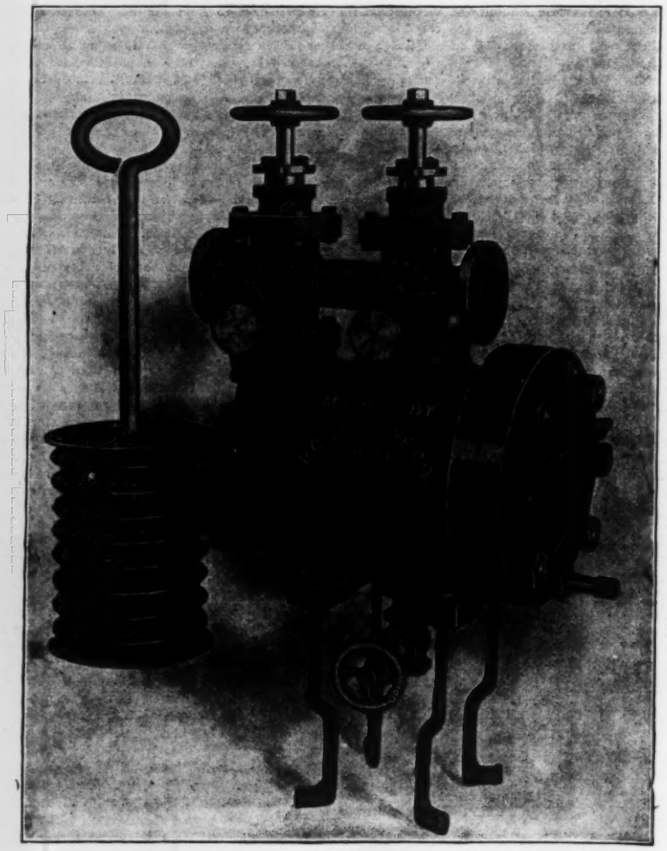


FIG. 1.—PERSPECTIVE VIEW OF ROSS FEED-WATER FILTER, SHOWING FILTER CAGE REMOVED.

The Ross Valve Co., Troy, N. Y., Makers.

The apparatus for removing oil from feed water, shown in the accompanying illustrations, was put on the market a few years ago in England by Messrs. Railton & Campbell, and largely introduced by them in ocean-going steamers. It is now being made in this country by the Ross Valve Co., of Troy, N. Y. The filter is placed between the feed pumps and the boiler. It consists essentially of a chamber containing a bag made of the fabric known as "Turkish toweling," so folded as to obtain a large area of filtering surface in a small space. The surface of the bag is formed into a series of deep circular corrugations by being drawn over the bronze skeleton shown at the left of the perspective view, and drawn down between each of the sections by means of strings wound around it. The area of the filtering surface is made from 250 to 1,000 times the area of the feed pipe, according to the service required. The threads of the Turkish toweling retain the oil until they become saturated with it, while they let the water pass through. The filter is so constructed that the water passes from the outer side of the bag through it and the metal skeleton to the interior of the latter, and thence to the outflow pipe, as shown in the sectional view. The oil gradually clogs up the filtering material, increasing the resistance to the passage of the water. This resistance is indicated by the difference in the readings of the two pressure gages, one on the inlet and one on the outlet side of the filter. When the difference in pressure reaches 2 or 3 lbs. per sq. in. the filter may be cleaned by reversing the direction of the current, allowing the wash water to run to waste, or by changing the filter bag, a fresh one always being kept in reserve. The head of the filter chamber may be opened, the filter bags changed, the skeleton and the bag being removed and replaced by means of the long handle seen in the half-tone cut, and the head replaced inside of five minutes. The washing of the filter by reversing the current of water is done by operating the valves shown in the sectional view in the following manner: The inlet valve, A, is first screwed down and closed; B is then closed, and the drain cock opened. Valve A is then opened a little and the current of water thus created washes the outside of the filter. A is then closed and B opened, causing water to pass from the boiler through the filter bag from the inside. The valve, A, is ingeniously made to perform the double function of a stop-valve and a by-pass valve, as may be seen in the sectional view.

We are informed that these filters are in use on most of the transatlantic steamers of the White Star and North German Lloyd lines, and that many of these vessels make a round trip without changing the filter cloth, merely washing it by reversing the flow, as before explained, as often as it clogs. The manufacturers are also finding considerable demand for these filters for use in steam power stations, and they are even sending them as far away as South Africa.

THE FAILURE OF A LARGE GAS HOLDER IN NEW YORK CITY.

In our last issue was given a brief description of the failure, on Dec. 13, of an immense gas tank or holder, while undergoing a contractor's test previous to being accepted by the Consolidated Gas Co., for whom it was being constructed by the Logan Iron Works, of Greenpoint, Brooklyn, N. Y.

With this issue we present two views of the wreck, affording a fair idea of the complete destruction of the tank. Fig. 1 is a view of the eastern half of the wreck, and shows the mass of plates, girders and braces so badly tangled and twisted that, although a large force of men was at once put to work to clear away the wreck, very little impression has been made even at this time.

The holder, according to the best obtainable data, was a 4-section telescoping tank, 174 ft. in diameter and 160 ft. high, when fully extended, with a retaining or sealing tank 178 ft. in diameter and 42 ft. deep, 17 ft. of which was above ground, as seen in Figs. 1 and 2, and 25 ft. below. For the benefit of those not conversant with gas holder design, we may explain that the retaining tank is simply a huge reservoir filled with water.

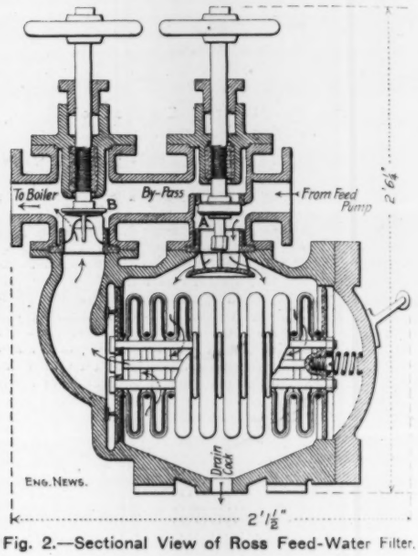


Fig. 2.—Sectional View of Ross Feed-Water Filter.

The gas-containing tank is like a great inverted tumbler, its lower edge immersed in the water of the tank, and is moved up or down as the gas is pumped in or drawn out. The gas-containing tank is subject, of course, to only a trifling pressure; but the tank which contains the water has to sustain hydrostatic pressure the same as any water reservoir or stand-pipe.

This great retaining tank, holding, when filled with water, some 1,044,621 cu. ft., burst through some cause not as yet determined, and all the water above the ground level instantly rushed out. Its volume was so great that buildings were wrecked by it, and it rushed through the streets with such force and volume that passers-by were carried for blocks in the flood as by a river. The total of deaths and fatal injuries due to this flood now numbers eight. Of course, the failure of the retaining tank brought down the entire overhead structure; and the thin plates of the gas-containing tank were bent and torn in all sorts of shapes by the force of the water and the collapse of the heavy overhead columns and girders.

The retaining tank, whose failure appears to have been the original cause of the disaster, was built up of plates varying in thickness from 7-16 in. at the top to 1¼ ins. at the bottom. The manner in which these plates were torn is admirably shown in our illustrations. It will be seen that the fracture went through the body of the plate and showed no tendency to follow the riveted seams. In Fig. 2 several 4-ft. plates are seen torn nearly straight across, the fracture, however, in some cases taking a curved form similar to that

seen in the fracture of a pane of glass. There were several similar tears at various other points on the portion of the tank still standing.

An examination of these fractures shows metal of a rather coarse crystalline structure at the center of the plate, shading off into a very fine grain at the surface, with here and there splinter edges much like broken case-hardened material. In one case two straight cracks appear running directly across the short dimension of a plate, in the unharmed standing portion. Of course, these fractures in these plates are not conclusive evidence that the metal from which they were rolled was too hard, or defective in other particulars. But they are certainly significant enough to call for a searching investigation into the specifications for these plates, their chemical composition, and their behavior under test. Our endeavors to obtain this information for the benefit of our readers have so far been unsuccessful; but it is certainly to be hoped that it may be brought forward in the Coroner's investigation which is to be made.

One feature in the design of the structure is made apparent in our photographs, and we are sure will be examined with interest by our readers. We refer to the support of the entire overhead structure on box-brackets bolted to the upper and thin portion of the retaining tank. These brackets, as may be seen in both figures, extend from the top of the retaining tank down to about the ground level. The question what stresses were set up in the plates of the tank by these brackets and the weight which they supported is one worth consideration. It may be, of course, that this method of support was a usual and proper one; but no reason is apparent why the overhead structure might not have been as well supported by independent piers of masonry, thus avoiding any possibility of distortion of the huge water-tank.

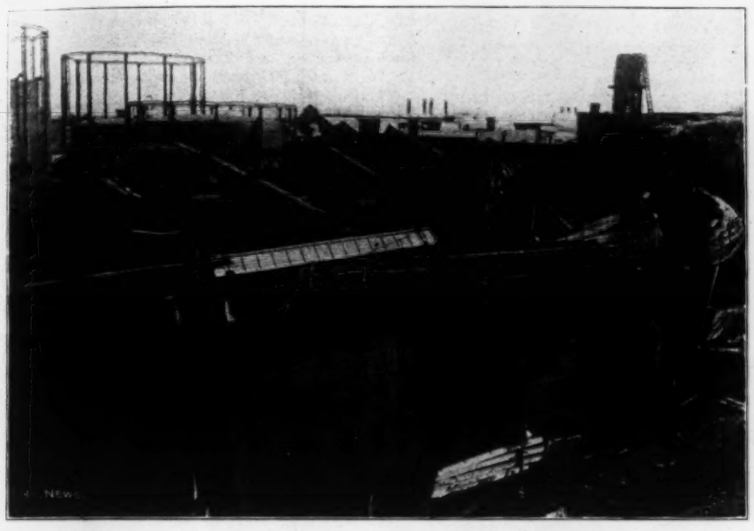


FIG. 1.—WRECK OF A LARGE GAS HOLDER; CONSOLIDATED GAS CO., NEW YORK CITY.

(From a photograph looking in the direction of the point of failure and showing the above-ground portion of the water tank.)

FIG. 2.—ONE OF THE TEARS IN THE STANDING PORTION OF THE WATER TANK.

(The fractured plates vary from ⅝-in. to about ⅞-in. in thickness.)

A MASONRY-PIER MOVED BY ICE was successfully put back into place on the St. Lawrence & Adirondack Ry. at the bridge over the Chateauguay River, in Quebec. The method adopted is described in a paper read by Mr. R. W. Leonard before the Canadian Society of Civil Engineers. The water was from 8 to 12 ft. deep, and the piers were built in a box-caisson sunk upon 75 piles, and finally riprapped. The ice-field which broke loose and caused the damage, was about 3 ft. thick, and the pier was shoved out of position at one end about 1 ft. Mr. Leonard then sunk a crib, 20 x 13 ft., alongside the pier; loaded this crib with stone and drove a line of nine piles on the outside of the crib. Four 50-ton. hydraulic jacks were then placed between the crib and the pier, and the latter was successfully pushed bask into place without a crack in the masonry. The pier, with its platform, weighed in all about 500 tons; the total cost of putting the pier back into its proper position was about $800.

A PAN-AMERICAN EXPOSITION, at Buffalo, N. Y., is planned for 1901, and the Mayor of that city has appointed a provisional committee to take decisive action in the matter. The City of Detroit is discussing a similar exposition.

A GREATER AMERICAN EXPOSITION in Omaha, in 1899, is proposed by the citizens of Omaha, and $105,000 was subscribed at a meeting Dec. 16. This sum is sufficient to secure the grounds and buildings of the recent Trans-Mississippi Exposition. A committee, with Mr. Edward Rosewater as chairman, has been appointed to prepare articles of incorporation for the enterprise.

THE HOUSE BILL FOR AIDING THE PHILADELphia Commercial Museum, by a grant of $350,000 to assist in providing permanent buildings, etc., passed by a vote of 142 to 70, under suspension of the rules. This permanent exposition, on which over half a million has already been expended, is intended wholly to promote the export trade of the United States. Its purpose is to show the products of all parts of the world; to educate manufacturers as to the articles most needed in foreign countries; to instruct merchants in packing and shipping goods, and in every way possible to aid in the development of foreign trade. The Councils of Philadelphia have contributed 56 acres of valuable ground within ten minutes ride of the City Hall; and the government appropriation is not available until Pennsylvania appropriates $300,000 more. The City of Philadelphia has already contributed $200,000 towards the buildings, and the State of Pennsylvania has voted $50,000, so that only $50,000 more must be raised. The plans for the buildings call for four acres of floor space, and numerous applications for this space have been received from manufacturers and merchants and dealers in the United States, Mexico, Central and South America, Africa, Australasia, India, Japan and Europe. Mr. William P. Wilson is the Director of the Museums.

THE EXPORTS OF THE UNITED STATES for 1898, in domestic merchandise, will amount to over $1,200,000,000 in value, as compared with less than $1,140,000,000 for the United Kingdom. Eight years ago, England shipped goods valued at $1,280,758,643—the greatest world's record, while that from the United States for the same year was worth $845,999,603. The November exports from the United States, says the Bureau of Statistics, broke the record with $127,483,467, exceeding that of November, 1897, by over $13,000,000, and by over $42,000,000 that of November, 1895. Including a few exports of foreign products, the total for November, 1898, was nearly $130,000,000, while the imports were only $52,109,560 in value.

TWENTY AMERICAN FREIGHT LOCOMOTIVES have been ordered for the Midland Railway Co., of England. The Schenectady Locomotive Works have the contract for ten of these and the Baldwin Locomotive Works are said to have the other ten. Within the last week the latter firm has closed contracts for 56 locomotives, 16 of which are for the Imperial Railways of China. The Schenectady Works are now shipping 27 locomotives constructed for the Nippoo Railway of Japan; and they are also completing 14 heavy compound consolidated locomotives for the Northern Pacific Ry. The Reading Railway Co. has made a contract with the Baldwin works for 25 freight engines and five heavy switching engines, especially designed for use on the Reading Subway, in Philadelphia, and on parts of the main line. The Baldwin works are also building ten large freight engines for the Chicago & Western Railroad Co. These contracts, coupled with numerous smaller orders, requires day and night work and a force of over 5,000 men in the Baldwin shops. The "Pall Mall Gazette" explains the English order as a consequence of the engineering strike in England. British locomotive builders are said to be only able to handle arrears of work and can take no new orders.

EXTRAORDINARY ACTIVITY IN THE IRON TRADE is reported from all the leading districts. The tonnage of the blast furnaces in operation on Dec. 1, according to the "Iron Age's" statistics was 235,528 gross tons per week, the highest figure ever recorded. Stocks of pig iron at the furnaces are reduced to 544,024 tons, as compared with 805,311 tons on July 1. Sales of pig iron and of steel in various shapes aggregating about 200,000 tons, were reported in one week at Pittsburg and Chicago. Prices of Bessemer pig iron have advanced 25 cents per ton. Fears are expressed that there will be a sudden scarcity of pig iron in the market, and that the conditions of the "boom" of 1879 and its disastrous consequences may be repeated. If a marked advance in prices should take place it will seriously curtail the export trade unless European prices are likewise advanced.

THE TWO RUSSIAN WARSHIPS now being built by the Cramps of Philadelphia, will have the following dimensions: The protected cruiser "Bear" will be 400 ft. long, 52 ft. beam, 6,500 tons displacement, 20,000 I. HP.; contract speed for 12 continuous hours, 22 knots; coal-bunker capacity, 1,400 tons. She will have a main battery of 12 6-in. rapid-fires, with 12 3-in. rapid-fires, and 6 47-mm. rapid-fires. There will be four torpedo tubes, with two of them under water. All the guns will be guarded by shields. The battleship will be 376 ft. long, 72 ft. beam, maximum draft 26 ft., 12,700 tons displacement, 16,000 I. HP., speed for 12 hours 18 knots, bunker capacity 2,000 tons. The side armor will be 7½ ft. deep and from 2 ins. to 9 ins. thick; above this will be 6-in. armor for the gun deck with 9-in. cross bulkheads. She will be armed with 12-in. guns in 10-in. barbettes and turrets, and with 6-in. and 3-in. rapid-fire guns, and six torpedo tubes. The full descriptions of these two ships are not yet published, but they are evidently to have great speed and an efficient rapid-fire batteries, with a minimum of armor.

PROPOSALS FOR RAISING THE "MAINE" and "Cristobal Colon" will soon be asked for by the Secretary of the Navy, as a result of the many offers received by the Navy Department from responsible firms, who are willing to undertake the work at their own risk.

THE HAVANA FLOATING DRY-DOCK, having a lifting capacity of 10,000 tons, is held to be floating and movable property by the American Evacuation Commission, and will be sold for the account of the Spanish government. This dock was built in England at a cost of $600,000; but is said to have been so badly used by the Spanish engineers that it is now not worth half that sum.

THE INFLUENCE OF COAL IN NAVAL WARFARE is indicated in the late report of the Bureau of Equipment of the U. S. Navy Department. During the fiscal year

the sum of $2,122,005 was paid for 452,551 tons of coal, or at the rate of $4.68 per ton, as compared with 138,318 tons, bought for the navy in the previous year of peace. Of the first amount 74,111 tons were purchased abroad at an average rate of $8.12 per ton, as compared with 5°,268 tons, at $6.68 per ton, bought abroad in the previous year. At Key West, with an original coal-shed capacity of only 3,000 tons—later raised to 9,000 tons—warships were often present having a bunker capacity of from 10,000 to 12,000 tons. The government first met the demand for colliers by the purchase of five vessels having an aggregate carrying capacity of about 13,000 tons; and by purchasing other foreign ships, the Bureau eventually had in Atlantic waters an efficient, armed collier fleet capable of carrying 50,000 tons of coal. At one time, at Hampton Roads, there were afloat on steam colliers, 40,000 tons of the best American coal, ready to be sent at an hour's notice to any point desired. Another experience of the war demonstrated the absolute necessity of providing either tank ships or distilling ships of large capacity for furnishing fresh water for boiler use. The distilling apparatus on our warships, with the notable exception of the "Oregon," was inadequate to keep up the supply of fresh water needed, and the boilers on blockading ships suffered from the want of fresh water. The Bureau believes that tank ships, such as are used for carrying oil in bulk, will be most useful in transporting water to a fleet. The purchase of fresh water for steaming purposes, under former methods, is now too expensive. For example, at Hampton Roads, 1,000 gallons of fresh water delivered to the ships costs $7.50; the same amount drawn from the mains at the Norfolk Navy Yard into a water-barge and towed to the ship, costs 30 cts. During the war, $2,067.50 was paid for 432,000 gallons of fresh water delivered to the "St Paul," at Tompkinsville, N. Y.; had this water been taken at the Brooklyn Navy Yard and towed in a barge to the ship, the cost would have been $43.25.

A UNIFORM .30 caliber, for small arms and machine guns, is recommended by the board of Army, Navy and Marine officers now in session in New York, with Col. Alfred Mordecai, U. S. A., presiding. The board proposes this caliber for all branches of the service, because the army is already armed with a number of such guns and large quantities are being daily turned out to meet the possible demand of an increased army. The cannelured cartridge-case is considered most suitable for use with these small arms and machine guns; provided, the change can be readily made in the army guns now in use.

THE 8-IN. CAST-STEEL, ONE-PIECE GUN, invented by Dr. R. J. Gatling, was submitted to the first of its series of tests at Sandy Hook on Dec. 15. Five rounds were fired with brown prismatic cocoa powder, in charges of 68, 132, 135, 141 and 142 lbs., and a projectile weighing 300 lbs. The gun successfully withstood these tests, though the highest chamber pressure recorded was about 37,000 lbs. per sq. in. This gun is cast, muzzle down, from a combination of steel and nickel, showing a tensile strength of 50 tons to the sq. in. To insure against blowholes a sinking head of 15 tons of metal is used in pouring. When bored the steel is found to be of fine quality, and homogeneous; but the chief claim of Dr. Gatling lies in his method of reheating the ingot and then cooling from the interior in such manner as to practically provide a series of shrunked bands about the bore. The full test includes 300 rounds, and the cast-steel gun must prove its equal efficiency with built-up and wire-wound guns before it will be recommended by the board having its test in charge. In 8-in. built-up guns an abnormal chamber-pressure of 100,000 lbs. has been recorded; and the Brown 5-in. wire-wound gun has often withstood pressure of 50,000 lbs., and one of 82,850 lbs.

THE LEAGUE OF ASSOCIATED ENGINEERS, with headquarters at the House of the Engineers' Club, in New York city, aims to bring closer together American engineers in civil life and those serving under the government in the engineering profession. It is also intended to foster a more active public interest in the engineering aspect of our national defense and to assist government engineers in their efforts to secure the highest possible efficiency both in material and in personnel. Technical education and training of a high order in these branches of the service are imperatively necessary; and in encouraging the necessary legislative measures the citizen engineer performs a patriotic duty and betters the standing of the profession generally. At the present time the Executive Committee of the League is engaged with H. R. bill No. 10,403, entitled "A bill to reorganize and increase the efficiency of the personnel of the Navy and Marine Corps of the United States." The League intends to press the passage of this bill, and any who have suggestions to make, or who can assist in this work, are asked to communicate with Mr. Stephen W. Baldwin, Chairman, care of The Engineers' Club, No. 374 5th Ave., New York.

THE PROPOSED DEEPENING OF THE CHANNEL at the entrance of New York Harbor is being examined by a special board of engineer officers, made up of Col. Henry M. Roberts, Lt.-Col. C. W. Raymond and Major H. M. Adams. The surveys and plans recommended by Col. Ludlow are being especially considered. These, as the best of three alternative routes, practically cover the deepening of the direct East channel to 35 ft., thus avoiding the long detour by the Gedney and Main channels, and saving several miles in entering the harbor.

A 30-FT. CHANNEL IN THE DELAWARE RIVER, 600 ft. wide, is again agitated by maritime interests in Philadelphia. The length of this channel would be about 56 miles and it would require the removal of 32,375,000 cu. yds. of mud, etc., and about 12,100 cu. yds. of rock. The estimated total cost would be $5,935,000, and the work could be finished in five years. The present channel is 26 ft. deep, but this is inadequate for the demands of commerce.

THE BALTIC-BLACK SEA SHIP CANAL, so often reported as a possible enterprise, will not be built, according to a communication from the Russian government to U. S. Consul-General Halloway, of St. Petersburg.

WATER POWER IN PORTO RICO is abundant and efficient, according to Gen. Roy Stone. The numerous small rivers have an average fall of 2,500 ft. in passing from the central mountainous country to the coast; and on these streams are many high water falls.

THE RAILWAY SYSTEM OF THE BERNESE OBERland, starting from Interlaken, Switzerland, has a total extent of a little over 42 miles, including the 7.8 miles of the Jungfrau railway now under construction, described in our issue of Dec. 15. From Interlaken to Zweilutschinen, 5 miles, ordinary locomotives are used; but beyond this point the system of traction is a mixed one, including both ordinary and rack rail lines. The maximum grade surmounted on the lines to Lauterbrunnen and to the Grindelwald is 12%; but the lines to Schynigeplatte and to the Wengeralp have rack rails for the whole length, and the maximum grade is 25%. The line to Murren is operated by a counterpoised cable, over a length of 4,526 ft., with an incline of 26%. These lines have a gage of 2.62 ft., and the rails usually weigh about 45 lbs. per yd. The cost of building the 14½ miles of the Interlaken-Lauterbrunnen-Grindelwald line, opened in 1890, was about $44,000 per mile; and 86% of the business is from tourists, amounting to annual gross receipts of $80,000. The rack-railways up the Schynigeplatte and Wengeralp, opened in 1893, cost nearly $80,000 per mile, with their 25% maximum grades. Interlaken is 1,863 ft. above sea level; Murren has an elevation of 5,376 ft.; Grindelwald of 3,467 ft., and the summit station of the Jungfrau line will be 13,668 ft. above sea level.

A COMBINED BRAKE COUPLING and angle-cock has been invented in which the cocks are automatically opened by the operation of coupling up the hose, which operation is performed by hand in the usual way. The main object is to prevent accidents caused by tampering with or neglect of these valves. The ordinary hose coupling shell is used, and is provided with an angle-cock valve connected by a link with a turn-plate on the back of the shell. This turn-plate is fitted with two claws, which grip the projecting flange of the mating shell, thus operating the valves, opening them when coupling, and closing them when uncoupling. The coupling gives the full air opening required and will couple and work with any standard coupling now in use, so that it can be introduced gradually. In case of a train parting the valves will remain open, thus releasing the air and causing the application of the brakes. The device has been tested under 100-lbs. pressure in the shops, but has not yet been in use on any cars. It is being introduced by W. & M. Cunningham, P. O. Box 340, Pittsburg, Pa.

THE TERM "SEMI-STEEL," which has recently been applied by some founders to cast-iron which has been improved by remelting with the addition of some steel scrap, is strongly objected to by Dr. Richard Moldenke, of Pittsburg. In a letter to the "Iron Trade Review," he says:

> The addition of steel scrap has simply extended the upper strength limit from 25,000 to 40,000 lbs. per sq. in., and the ductility from 0.3 to about 0.75%, but has not made a new class of material by any means, all the properties being those of cast-iron. . . . The use of the term "semi-steel" conveys to the minds of modern men an impression similar to the name of some patent medicine.

THE WORLD'S PRODUCTION OF GOLD in the last five years, says Mr. George E. Roberts, Director of the Mint, has amounted to $977,622,100. The industries consumed $300,000,000 of this. The stocks of gold in sight in European banks and government treasuries, from December, 1892, to December, 1897, increased about $550,000,000, or over 40%. In these five years the stock of gold in the United States increased $95,457,000; and the increase in Australia, Canada and South America was $15,000,000.

THE MONEY IN CIRCULATION IN THE UNITED States, on Dec. 1, was $1,886,879,504, or nearly $165,800,000 more than on the same date one year ago. Gold coin alone shows a gain of nearly $114,500,000 in this period; standard silver dollars show an increase of $2,700,000, and subsidiary silver coin, $5,100,000. U. S. Treasury experts, on a basis of a population of 75,194,000, estimate the circulation at $25.09 per capita, or $1.70 more than one year ago.

THE U. S. GENERAL LAND OFFICE, according to its report for the fiscal year ending June 30, 1898, recorded 99,806 entries of land, in all classes, covering 12,909,697 acres. The cash receipts from sales amounted to $1,391,393, and from fees and commissions the office received $853,265. The 30,293 agricultural patents covered about 4,846,880 acres, and the 1,259 mineral and mill site patents covered 31,605 acres, and railroad land grants amounted to 1,069,534 acres. The estimated unreserved and unappropriated land amounts to 579,368,274 acres, exclusive of Alaska.

THE WERNWAG WOODEN BRIDGE, over the White River, at Indianapolis, Ind., was built in 1831-33, and is still standing in fair condition, according to a paper read by Mr. Edward Hill before the Indiana Engineering Society and published in the "Proceedings" of that Society for 1898. The bridge is on the old National Road, and was contracted for on July 26, 1831, by Wm. H. Wernwag and Walter Blake for $18,000, and finished in 1833. There are two spans of 170 ft. each, and the timber used was yellow poplar. Each span consists of three arched beams, which carry all the load; and each one is made of three 5½ × 11½-in. sticks placed one over the other, with 1½ ins. between sticks for packing; the arch being thus 3 ft. 1½ ins. deep. The posts are spaced 8 ft. 9 ins. apart, and are set radial to the curve of the arch. The original abutments stand, but the pier has been practically rebuilt. After 64 years continual service this bridge was straightened and repaired by the City of Indianapolis in 1897.

THE ELECTRIC SEASONING OF WOOD is mentioned by the London "Builder." The timber is immersed about half its depth in a tank of water, and an electric current is applied through a metallic conductor, so arranged as to distribute the current through the whole area. In about 4 minutes the sap begins to exude at the lower end of the stick, and in 6 hours it is all extracted. In another tank an antiseptic solution is then forced into the empty pores by an electro-capillary process. The cost of doing all this is not stated.

BOOK REVIEWS.

MODELLVERSUCHE UBER DEN EINFLUSS DER FORM UND GROSSE DES CANALQUERSCHNITTES AUF DEN SCHIFFSWIDERSTAND.—Von H. Engels, Geh. Hofrath, Professor an den Technischen Hochschule in Dresden. Berlin, 1898: Wilhelm Ernst & Sohn. Paper; 14 × 10½ ins; pp. 12; two diagrams. 3 marks.

This treatise relates to experiments, made with models, upon the influence of the form and dimensions of the cross-sections of canals upon the resistance of ships in transit. Seven forms of canals were experimentel upon, with varying widths, at water surface, but constant depths; though other experiments are given in which both dimensions are widely varied in canals with inclined sides. These experiments are all tabulated and the apparatus used is illustrated. Professor Engels seemingly favors a section which is deepest at the middle; with slight upward slopes to the foot of the side-slopes.

TOPOGRAPHICAL SURVEYING. — Van Nostrand's Science Series, No. 72. Including: Topographical Surveying, by Geo. J. Specht, C. E.; New Methods in Topographical Surveying, by Prof. A. S. Hardy; Geometry of Position Applied to Surveying, by John B. McMasters, C. E.; Co-ordinate Surveying, by Henry F. Walling, C. E. Second edition; revised. New York: Van Nostrand Co. Cloth; 6 × 3⅝ ins.; pp. 210. 50 cents.

The earlier edition of this series of essays having been exhausted, the present issue has been revised in text and diagrams to agree with the latest practice. The titles are sufficiently descriptive of the purpose of the handbook. The chapter by Professor Hardy is devoted to the application of photography to surveying, and describes the general practice in the field and in the office.

TECHNICAL EDUCATION (FRANCE).—Copy of "Report on French Technical Education," by Mr. Charles Copeland Perry, recently issued by the Science and Art Department. Eyre & Spottiswoode, Government Printers, London. Pamph.; 8vo.; pp. 59. Price, three pence.

This report is divided into three parts: 1. Recent Legislation on French Primary Technical Education. 2. Schools Visited—Primary and Secondary. 3. Summary. A French law in 1880 provided for the establishment of schools "manuelles d'apprentissage," to "develop in youths intended for manual trades the requisite dexterity and technical knowledge. The law was practically a dead letter until 1888, and it was not until 1892, when a new category of schools "pratiques de commerce on d'industrie" was created, that the present system of French industrial education was seriously begun. The report is a carefully written account of the difficulties that have been encountered in arriving at a correct theory or scheme of industrial or trade education in France, of the mistakes that have been made, the beneficial results already visible, and generally of the present status of these schools.